DEVELOPMENT DOCUMENT

for

PROPOSED EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

STEEL MAKING SEGMENT

of the

IRON AND STEEL MANUFACTURING POINT SOURCE CATEGORY

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January, 1974

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ABSTRACT

This document presents the findings of an extensive study of the raw steel making operations of the iron and steel industry for the purpose of developing effluent limitations guidelines, Federal standards of performance, and pretreatment standards for this segment of the industry to implement Sections 304, 306, and 307 of the "Act".

Effluent limitations guidelines contained herein set forth the effluent quality attainable through the application of the best practicable control technology currently available (BPCTCA) and the effluent quality attainable through the application of the best available technology economically achievable (BATEA) which must be achieved by existing point sources by July 1, 1977, and July 1, 1983, respectively. The standards of performance for new sources (NSPS) contained herein set forth the effluent quality which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

Supporting data and rationale for development of the proposed effluent limitations guidelines and standards of performance are contained in this report.

Notice: These are tentative recommendations based upon information in this report and are subject to change based upon comments received and further internal review by EPA.

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SECTION I

CONCLUSIONS

For the purpose of establishing effluent guidelines and standards of performance for the raw steel making operations of the iron and steel industry, the industry was divided into subcategories as follows:

- I By Product Coke Subcategory
- II Beehive Coke Subcategory
- III Sintering Subcategory
- IV Blast Furnace (Iron) Subcategory
- V Blast Furnace (Ferromanganese) Subcategory
- VI Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory
- VII Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory
- VIII Open Hearth Furnace Subcategory
- IX Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory
- X Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory
- XI Vacuum Degassing Subcategory
- XII Continuous Casting Subcategory

The selection of these subcategories was based upon distinct differences in type of products produced, production processes, raw materials used, waste waters generated and control and treatment technologies employed. Subsequent waste characterizations of individual plants substantiated the validity of this subcategorization.

The waste characterizations of individual plants visited during this study, and the guidelines developed as a result of the data collected, relate only to the aqueous discharges from the facilities, excluding non-contact cooling waters. Consideration will be given at a later date to proposing thermal discharge limitations on process and noncontact cooling waters. Consideration will also be given at a later date to proposing effluent limitations on the runoffs from stock piles, slag pits and other fugitive waste sources.

The effluent guidelines established in this study are not dependent upon the raw water intake quality. The limitations were derived by determining the minimum flows, in volume per unit weight of product, that can be achieved by good water conservation techniques and by determining the effluent concentrations of the pollutant parameters that can be achieved by treatment technology. The product of these is the effluent limitations proposed.

The plant raw waste loads however, are, out of necessity, a net number that reflects the pickup of contaminants across a production process in a single pass. It was necessary to establish the raw waste load in this manner in order to obtain a meaningful comparison of wastes generated during production from a range of plants surveyed. Some plants utilized once-through water systems, while many others used varying degrees of reuse and/or recycle. Since the gross waste load to be treated generally varied depending upon the extent of recycle used in the system, the only way a meaningful raw waste load for a production process could be determined was on a net basis.

As presented in Table 89, an initial capital investment of approximately $144.9 million with annual capital and operating costs of $39.9 million would be required by the industry to comply with the 1977 guidelines. An additional capital investment of approximately $122.3 million with added annual capital and operating costs of about $42.5 million would be needed to comply with th 1983 guidelines. Costs may vary depending upon such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and the extent of preliminary modifications required to accept the necessary control and treatment devices.

The subcategories listed previously and this report represent Phase I of the study to establish effluent guidelines for the steel industry. Additional work to be completed under Phase II of this program includes the remainder of SIC Industry Nos. 3312, 3315, 3316, 3317, 3321, 3322, and 3323 as outlined in the 1967 SIC Manual.

SECTION II

RECCMMENDATIONS

The proposed effluent limitations guidelines for the iron and steel industry representing the effluent quality obtainable by existing point sources through the application of the best practicable control technology currently available (BPCTCA or Level I) for each industry subcategory, are as follows:

I. By Product Coke Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
*Cyanide (T)	0.0438	0.0219
Phenol	0.0029	0.0015
Ammonia	0.1825	0.0912
BOD5	0.2190	0.1095
Oil & Grease	0.0219	0.0109
Suspended Solids	0.0730	0.0365
pH	6.0 to 9.0	

*Cyanide (T): Total cyanide. Reference ASTM D2036-72.

II. Beehive Coke Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
*Cyanide (T)		
Phenol		
Ammonia	No discharge of process waste water pollutants to navigable waters	
BOD		
Sulfide		
Oil & Grease		
Suspended Solids		
pH		

*Cyanide (T): Total cyanide. Reference ASTM D2036-72.

III. Sintering Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0208	0.0104
Oil & Grease	0.0042	0.0021
pH	6.0 to 9.0	

IV. Blast Furnace (Iron) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0521	0.0260
*Cyanide (T)	0.0156	0.0078
Phenol	0.0042	0.0021
Ammonia	0.1303	0.0651
pH	6.0 to 9.0	

V. Blast Furnace (Ferromanganese) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.2086	0.1043
*Cyanide (T)	0.0625	0.0312
Phenol	0.0083	0.0042
Ammonia	0.4172	0.2086
pH	6.0 to 9.0	

*Cyanides (T): Total cyanide. Reference ASTM D2036-72.

VI. Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	No discharge of process waste water pollutants to navigable waters	
pH		

VII. Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0208	0.0104
pH	6.0 to 9.0	

VIII. Open Hearth Furnace Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0208	0.0104
pH	6.0 to 9.0	

IX. Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	No discharge of process waste water pollutants to navigable waters	
pH		

X. Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0208	0.0104
pH	6.0 to 9.0	

XI. Vacuum Degassing Subcategory

BPCTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameters	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
pH	6.0 to 9.0	

XII. Continuous Casting Subcategory

BCPTCA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0521	0.0260
Oil & Grease	0.0156	0.0078
pH	6.0 to 9.0	

The proposed effluent guidelines representing the effluent quality obtainable by existing point sources through the application of the best available technology economically achievable (BATEA or Level II) for each industry subcategory are as follows:

I. By Product Coke Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
*Cyanide (A)	0.0002	0.0001
Phenol	0.0004	0.0002
Ammonia	0.0083	0.0042
BOD_5	0.0166	0.0083
Sulfide	0.0003	0.0001
Oil & Grease	0.0083	0.0042
Suspended solids	0.0083	0.0042
pH	6.0 to 9.0	

II. Beehive Coke Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
*Cyanide (A)		
Phenol		
Ammonia	No discharge of process waste water pollutants to navigable waters	
BOD_5		
Sulfide		
Oil & Grease		
Suspended Solids		
pH		

*Cyanide (A): Cyanide amenable to chlorination. Reference ASTM D 2036-72.

III. Sintering Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
Oil & Grease	0.0042	0.0021
Sulfide	0.00012	0.00006
Fluoride	0.0083	0.0042
pH	6.0 to 9.0	

IV. Blast Furnace (Iron) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameters	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
*Cyanide (A)	0.00026	0.00013
Phenol	0.00052	0.00026
Ammonia	0.0104	0.0052
Sulfide	0.00031	0.00016
Fluoride	0.0208	0.0104
pH	6.0 to 9.0	

*Cyanide (A): Cyanides amenable to chlorination. Reference ASTM D2036-72.

V. Blast Furnace (Ferromanganese) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0208	0.0104
*Cyanide (A)	0.00052	0.00026
Phenol	0.00104	0.00052
Ammonia	0.0208	0.0104
Sulfide	0.00062	0.00031
Manganese	0.0104	0.0052
pH	6.0 to 9.0	

*Cyanide (A): Cyanides amenable to chlorination. Reference D 2036 - 72.

VI. Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	No discharge of process waste water pollutants to navigable waters	
Fluoride		
pH		

VII. Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
Fluoride	0.0083	0.0042
pH	6.0 to 9.0	

VIII. Open Hearth Furnace Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameters	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
Fluoride	0.0083	0.0042
Nitrate (as NO_3)	0.0187	0.0094
Zinc	0.0021	0.0010
pH	6.0 to 9.0	

IX. Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	No discharge of process waste water pollutants to navigable waters	
Zinc		
Fluoride		
pH		

X. Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
Fluoride	0.0083	0.0042
Zinc	0.0021	0.0010
pH	6.0 to 9.0	

XI. Vacuum Degassing Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0052	0.0026
Zinc	0.0010	0.0005
Manganese	0.0010	0.0005
Lead	0.0001	0.00005
Nitrate (as NO_3)	0.0094	0.0047
pH	6.0 to 9.0	

XII. Continuous Casting Subcategory

BATEA Effluent Limitations
Units: kg pollutant per kkg of product
or: lb pollutant per 1,000 lb of product

Pollutant Parameter	Maximum for any One Day Period Shall Not Exceed	Maximum Average of Daily Values for any Period of 30 Consecutive Days
Suspended Solids	0.0104	0.0052
Oil & Grease	0.0104	0.0052
pH	6.0 to 9.0	

The proposed effluent guidelines representing the effluent quality attainable by new sources (NSPS or Level III) through the application of the best available demonstrated control technology, (BADCT) processes, operating methods or other alternatives for each industry sub-category are as follows:

Same as BATEA for all categories.

SECTION III

INTRODUCTION

Purpose and Authority

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achieveable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) to the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be acheivable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods and other alternatives.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973, a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the iron and steel industry which was included within the list published January 16, 1973.

Summary of Methods Used for Development of the Effluent Limitations Guidelines and Standards of Performance

The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first studied for the purpose of determining whether separate limitations and standards would be required for different segments within a point source category. The analysis was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw waste characteristics for each subcategory were then identified. This included an analyses of (1) The source and volume of water used in the process employed and the sources of waste and wastewaters in the plant; and (2) the constituents (including thermal) of all wastewaters including toxic constituents and other constituents which result in taste, odor, and color in water. The constituents of wastewaters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both inplant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology and the required implementation time was also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available," "best available technology economically achievable" and the "best available demonstrated control technology, processes, operating methods, or other alternatives." In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements) and other factors.

The data for identification and analyses were derived from a number of sources. These sources included EPA research information, EPA and State environmental personnel, trade associations, published literature, qualified technical consultation, and on-site visits including sampling programs and interviews at steel plants throughout the United States which were known to have above average waste treatment facilities. All references used in developing the guidelines for effluent limitations and standards of performance for new sources reported herein are listed in Section XIII of this document.

Operating steel plants were visited and information and samples were obtained on from one to five plants in each of the subcategories. Both in-process and end-of-pipe data were obtained as a basis for determining water use rates and capabilities and effluent loads. The permit application data was of limited value for the purposes of this study since most of this data is on outfalls serving more than one operation and frequently was deficient in one or more of the components needed to correlate the data. The following capital and operating cost data sheet and test data sheets, e.g. EPA Form B, for raw waste, treated effluent, and service water were given to the plants, at the time of the sampling visit, for completion relative to the operation or operations studied at a given plant. The plants were requested to return this information, together with production data to the study contractor.

General Description of the Industry

Although the making of steel appears to be simple, many problems are encountered when a great quantity of raw materials and resources are brought together to ultimately produce steel. Steel mills may range from comparatively small plants to completely integrated steel complexes. Even the smallest of plants will generally represent a fair sized industrial complex. Because of the wide product range, the operations will vary with each facility. The steel oriented may fail to realize that those unfamiliar with the steel industry may find it difficult to comprehend the complexity of this giant operation.

It was not until the mid-fifties that the industry began to look at iron and steelmaking as unit operations that required a better knowledge of the kinetics of competing reactions. Since this initial change in thinking, the adoption of advanced technology has become a way of life for the steel industry.

Approximately ninety-two per cent (92%) of the 1972 total United States annual steel ingot production was produced by fifteen major steel corporations. This total also represents 22.5% of the world total of 556,875,000 metric tons (625,000,000 ingot tons). Table 1 presents the breakdown by corporation. The year of record for steel ingot production was 1969 with 127,887,000 kkg (141,000,000 ingot tons) being produced. Table 2 presents a breakdown by area of the major corporations and their production levels of coke, iron, and steel. Approximately 59,000,000 kkg (65,000,000 tons), of coke, 75,000,000 kkg (83,000,000 tons) of iron, and 121,000,000 kkg (134,000,000 tons) of steel were produced for the year 1972.

Product Classification

TABLE 1

United States Annual Steel Ingot Ton Production
Major Producers
1972

	Metric Tons/Year	Ingot Tons/Year
United States Steel	31,750,000	35,000,000
Bethlehem Steel	19,960,000	22,000,000
Republic Steel	9,980,000	11,000,000
National Steel	9,520,000	10,500,000
Armco Steel	7,710,000	8,500,000
Jones & Laughlin Steel	7,280,000	8,000,000
Inland Steel	6,800,000	7,500,000
Youngstown Sheet & Tube	5,440,000	6,000,000
Wheeling Pittsburgh	3,540,000	3,900,000
Kaiser	2,720,000	3,000,000
McLouth	1,819,000	2,000,000
Colorado Fuel & Iron	1,360,000	1,500,000
Sharon	1,360,000	1,500,000
Interlake	907,000	1,000,000
Alan Wood	907,000	1,000,000

TABLE 2

Production Levels by Area
Metric Tons
(Metric Tons X1.102 = Short Tons)

	Coke	Iron	Steel
PITTSBURGH, PENNSYLVANIA AREA			
United States Steel			
Duquesne	---	2,750,000	3,720,000
Edgar Thompson	---	858,000	1,600,000
Homestead	---	1,920,000	3,100,000
Clairton	7,150,000	492,000	---
Bethlehem Steel			
Bethlehem	1,900,000	2,720,000	2,270,000
Johnstown	1,260,000	1,720,000	1,990,000
Jones & Laughlin Steel			
Aliquippa	1,520,000	2,420,000	2,980,000
Pittsburgh	1,800,000	844,000	1,270,000
Wheeling-Pittsburgh Steel			
Monessen	563,000	951,000	1,450,000
Sharon			
Roemer	---	939,000	1,360,000
Fairmont, W. Va.	215,000	---	---
CHICAGO, ILLINOIS & GARY, INDIANA			
United States Steel			
Gary	4,560,000	4,560,000	3,590,000
South Works, Chicago, Il.	---	1,490,000	2,060,000
Bethlehem Steel			
Burns Harbor	N.A.	3,310,000	4,440,000
Inland Steel			
Indiana Harbor	2,910,000	4,900,000	6,800,000

TABLE 2 (Cont'd.)

<u>Republic Steel</u>			
Chicago	N.A.	1,090,000	1,810,000
<u>Youngstown Sheet & Tube</u>			
East Chicago, Indiana	1,340,000	1,810,000	2,630,000
<u>Interlake</u>			
Chicago	613,000	680,000	907,000
Toledo	546,000	740,000	---
YOUNGSTOWN, OHIO AREA			
<u>United States Steel</u>			
Youngstown		978,000	1,620,000
<u>Armco Steel</u>			
Middletown, Ohio	281,000	800,000	1,420,000
Hamilton, Ohio	610,000	501,000	975,000
<u>Republic Steel</u>			
Youngstown, Ohio	874,000	728,000	---
Warren, Ohio	430,000	1,640,000	1,810,000
<u>Youngstown Sheet & Tube</u>			
Campbell	1,320,000	853,000	1,570,000
Brier Hill	330,000	573,000	1,040,000
BUFFALO, NEW YORK AREA			
<u>Bethlehem Steel</u>			
Lackawanna	2,050,000	4,490,000	5,970,000
<u>National Steel</u>			
Hanna, Buffalo	---	272,000	---
<u>Republic Steel</u>			
Buffalo	---	497,000	680,000
<u>Donner-Hanna Coal</u>			
Buffalo	546,000	(Serves National & Republic)	

TABLE 2 (Cont'd.)

WHEELING, WEST VIRGINIA AREA			
National Steel			
Weirton	1,570,000	2,170,000	3,230,000
Wheeling-Pittsburgh			
Wheeling	---	1,400,000	2,090,000
Steubenville, Ohio	1,590,000	---	---
DETROIT, MICHIGAN AREA			
National Steel			
Ecorse, Michigan	1,620,000	2,400,000	3,260,000
McLouth Steel			
Trenton, Michigan	---	1,660,000	1,810,000
CLEVELAND, OHIO AREA			
Republic Steel			
Cleveland	1,890,000	2,450,000	3,180,000
Jones & Laughlin Steel			
Cleveland	---	1,750,000	2,190,000
United States Steel			
Lorain Works	N.A.	1,210,000	1,870,000
MISCELLANEOUS AREAS			
United States Steel			
Fairless-Philadelphia	993,000	2,160,000	3,300,000
Fairfield-Alabama	2,270,000	1,880,000	3,060,000
Geneva-Provo, Utah	1,660,000	1,780,000	2,060,000
Baytown, Texas	---	---	500,000
National Steel			
Granite City-St. Louis, Mo.	710,000	907,000	1,360,000

TABLE 2 (Cont'd.)

<u>Armco Steel</u>			
Ashland, Kentucky	---	1,040,000	1,440,000
Houston, Texas	365,000	550,000	700,000
<u>Bethlehem Steel</u>			
Sparrows Point, Md.	3,010,000	5,560,000	7,420,000
<u>Republic Steel</u>			
Gadsden, Alabama	464,000	---	---
Birmingham, Alabama	315,000	895,000	1,360,000
Massillon, Ohio	166,000	310,000	---
Canton, Ohio	---	290,000	800,000
<u>Kaiser Steel</u>			
Fontana, California	1,360,000	2,070,000	2,720,000
<u>CF&I Steel Corporation</u>			
Pueblo, Colorado	1,040,000	939,000	1,360,000
Roebling, N.J.			230,000
<u>Alan Wood</u>			
Conshohocken, Pa.	525,000	544,000	907,000
<u>Interlake</u>			
Erie, Pennsylvania	242,000	380,000	---

The U. S. Bureau of Census, Census of Manufacturers classifies the steel industry under Major Group 33 - Primary Metal Industries. This phase of study covers the coking (excluding the technology related to coke plant wastewater treatment by multiple effect evaporation), blast furnace - sinter plant, iron casting, steel manufacturing and steel casting segments of SIC Industry No. 3312 as it pertains to the iron and carbon steel industry. This includes all processes, subprocesses, and alternate processes involved in the manufacture of intermediate or finished products in the above categories. A detailed list of product codes within the industry classification code 3312 is included in Table 3.

Anticipated Industry Growth

Steel in the United States is a $22.47 billion a year business. The industry is third in the nation, behind the automotive and petroluem industries, in the value of its total shipments and, with 487,000 employees, is second only to the automotive industry in the number of people who work for it. Over the decade since 1962, the steel industry has grown 60% from sales of $14.0 to $22.47 billion.

In 1972 steel climbed back from its worst market in over a decade showing a steady improvement in the early part of the year. Both raw steel production and finished mill product shipments were up substantially from 12-year lows reached late summer of 1971. As steel demand improved, so did steel employment. The number of persons carried on domestic steelmaker payrolls increased steadily during the first quarter, after hitting a 32-year low in November, 1971. Just how fast the economic position of the nation's steel industry improves, however, depends to a large extent on one important imponderable: imports. In the first two months of 1972, for instance, foreign steel accounted for one-seventh of the nation's apparent steel consumption.

General Description of the Operations

Three basic steps are involved in the production of steel. First, coal is converted to pure carbon, coke. Second, coke is then combined with iron ore and limestone in a blast furnace to produce iron. Third, the iron is purified into steel in either an open hearth, basic oxygen, or electric furnace. Further refinements include degassing by subjecting the steel to a high vacuum. Steel that is not cast into ingot molds can be cast into a process called continuous casting. The flow of a typical steel mill is shown in Figure 1.

Coke plants are operated as parts of integrated steel mills to supply the coke necessary for the production of iron in blast furnaces. Nearly all coke plants today are byproduct plants, i.e., products such as coke oven gas, coal tar, crude and refined light oils, ammonium sulfate, anhydrous ammonia, ammonia liquor, and naphthalene are produced in addition to coke. A very small portion of coke is also produced in the

TABLE 3

Product Classification by SIC Code(3312)
for the Iron and Steel Industry

BLAST FURNACES, STEEL WORKS, AND ROLLING AND FINISHING MILLS

Blast Furnaces (Including Coke Ovens), Steel Works, and Rolling Mills

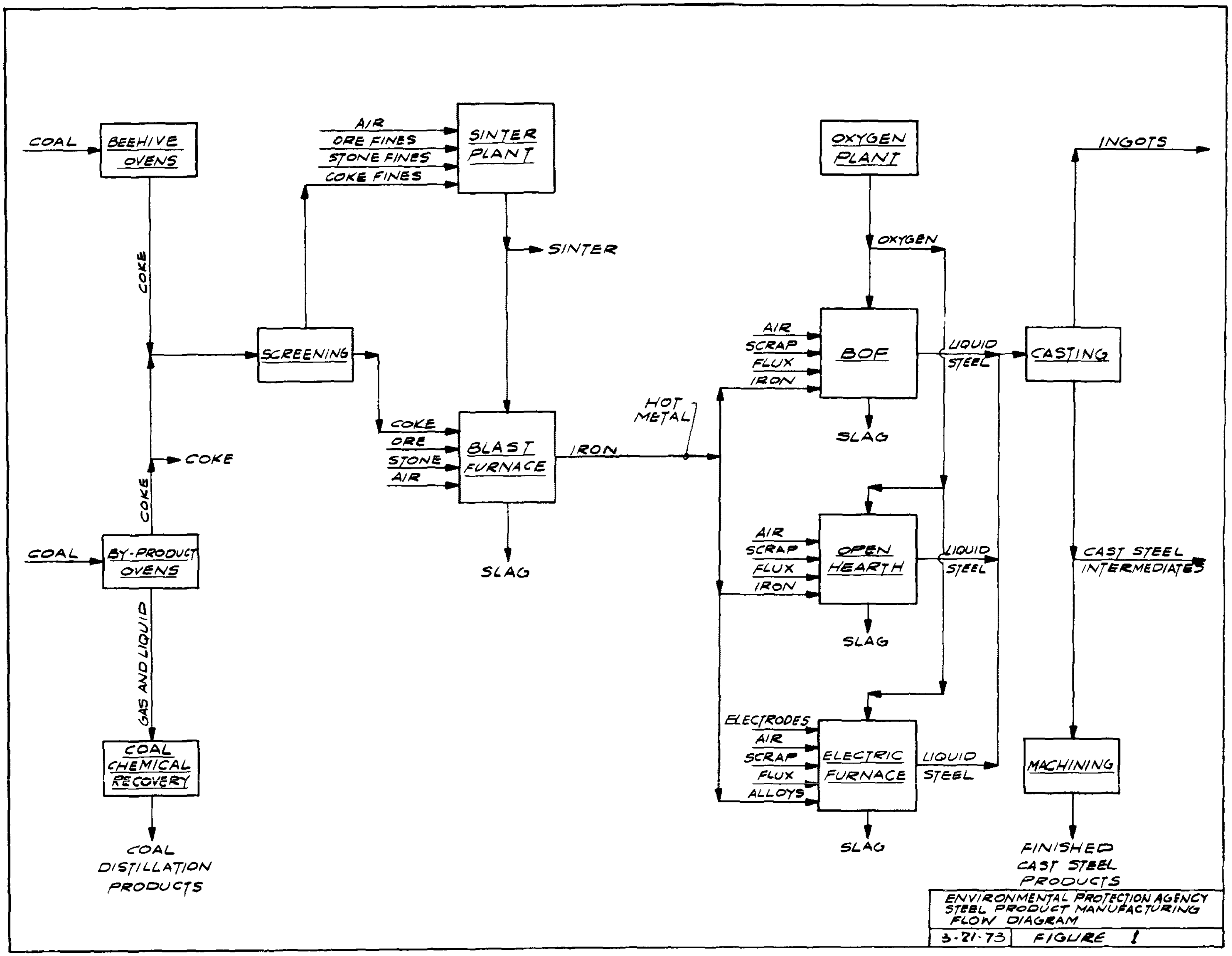
Establishments primarily engaged in manufacturing hot metal, pig iron, silvery pig iron, and ferroalloys from iron ore and iron and steel scrap; converting pig iron, scrap iron and scrap steel into steel; and in hot rolling iron and steel into basic shapes such as plates, sheets, strips, rods, bars, and tubing. Merchant blast furnaces and by-product or beehive coke ovens are also included in this industry.

Armor plate, made in steel works or rolling mills
Axles, rolled or forged: made in steel works or rolling mills
Bars, iron: made in steel works or rolling mills
Bars, steel: Made in steel works or hot rolling mills
Beehive coke oven products
Billets, steel
Blackplate
Blast furnace products
Blooms
Car wheels, rolled
Chemical recovery coke oven products
Coal gas, derived from chemical recovery coke ovens
Coal tar crudes, derived from chemical recovery coke ovens
Plates, made in steel works or rolling mills
Rail joints and fastenings, made in steel works or rolling mills
Railroad crossings, iron and steel: made in steel works or rolling mills
Rails, iron and steel
Rails, rerolled or renewed
Rods, iron and steel: made in steel works or rolling mills
Rounds, tube
Sheet pilings, plain: iron and steel--made in steel works or rolling mills
Sheets, iron and steel; made in steel works or rolling mills
Shell slugs, steel: made in steel works or rolling mills
Skelp, iron and steel
Slabs, steel

TABLE 3 (Cont'd.)

Coke, produced in beehive ovens
Coke, produced in chemical recovery coke ovens
Cold rolled strip steel, flat bright: made in hot rolling mills
Distillates, derived from chemical recovery coke ovens
Fence posts, iron and steel: made in steelworks or rolling mills
Ferroalloys, produced in blast furnaces
Flats, iron and steel: made in steel works and hot rolling mills
Forgings, iron and steel: made in steel works or rolling mills
Frogs, iron and steel: made in steel works or rolling mills
Galvanized hoops, pipes, plates, sheets, and strips: iron and steel
Gun forgings, iron and steel: made in steel works or rolling mills
Hoops, galvanized iron and steel: made in steel works or hot rolling mills
Hot rolled iron and steel products
Ingots, steel
Iron, pig
Iron sinter, made in steel mills
Nut rods, iron and steel: made in steel works or rolling mills
Pipe, iron and steel: made in steel works or rolling mills

Spiegeleisen, made in blast furnaces
Spikes and spike rods, made in steel works or rolling mills
Sponge iron
Stainless steel
Steel works producing bars, rods, plates, sheets, structural shapes, etc.
Strips, galvanized iron and steel: made in steel works or rolling mills
Strips, iron and steel: made in steel works or hot rolling mills
Structural shapes, iron and steel
Tar, derived from chemical recovery coke ovens
Terneplate
Ternes, iron and steel: long or short
Tie plates, iron and steel
Tin free steel
Tin plate
Tool steel
Tube rounds
Tubes, iron and steel: made in steel works or rolling mills
Tubing, seamless: steel
Well casings, iron and steel: made in steel works or rolling mills
Wheels, car and locomotive: iron and steel--"mitse"
Wire products, iron and steel: made in steel works or rolling mills
Wrought pipe and tubing, made in steel works or rolling mills


COAL
BEEHIVE OVENS
COKE
COAL
BY-PRODUCT OVENS
COKE
COKE
GAS AND LIQUID
COAL CHEMICAL RECOVERY
COAL DISTILLATION PRODUCTS
SCREENING
AIR
ORE FINES
STONE FINES
COKE FINES
SINTER PLANT
SINTER
COKE
ORE
STONE
AIR
BLAST FURNACE
SLAG
IRON
HOT METAL
OXYGEN PLANT
OXYGEN
AIR
SCRAP
FLUX
IRON
BOF
SLAG
LIQUID STEEL
AIR
SCRAP
FLUX
IRON
OPEN HEARTH
SLAG
LIQUID STEEL
ELECTRODES
AIR
SCRAP
FLUX
ALLOYS
ELECTRIC FURNACE
SLAG
LIQUID STEEL
CASTING
INGOTS
CAST STEEL INTERMEDIATES
MACHINING
FINISHED CAST STEEL PRODUCTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL PRODUCT MANUFACTURING
FLOW DIAGRAM
3·21·73
FIGURE 1

beehive coke process which is also discussed in this report. A by-product coke plant consists essentially of the ovens in which bituminous coal is heated, out of contact with air, to drive off the volatile components. The residue remaining in the ovens is coke; the volatile components are recovered and processed in the by-product plant to produce tar, light oils, and other materials of potential value, including coke oven gas.

Molten iron for subsequent steelmaking operations is normally produced in a blast furance. The blast furnace process consists essentially of charging iron ore, limestone, and coke into the top of the furnace and blowing heated air into the bottom. Combustion of the coke provides the heat necessary to obtain the temperature at which the metallurigical reducing reactions take place. The function of the limestone is to form a slag, fluid at the furnace temperature, which combines with unwanted impurities in the ore. One and eight tenths kkg of ore, 0.45 kkg of coke, 0.45 kkg of limestone and 3.2 kkg of air (2, 0.5, 0.5 and 3.5 tons respectively) produce approximately 0.9 kkg of iron, 0.45 kkg of slag and 4.5 kkg of blast furnace gas containing the fines of the burden carried out by the blast (one ton of iron, 0.5 tons of slag and 5 tons of gas). These fines are referred to as flue dust. Molten iron is periodically withdrawn from the bottom of the furnace; the fluid slag which floats on top of the iron is also periodically withdrawn from the furnace. Blast furnace flue gas has considerable heating value and, after cleaning, is burned to preheat the air blast to the furnace.

The blast furnace auxiliaries consist of the stoves in which the blast is preheated, the dry dust catchers in which the bulk of the flue dust is recovered, primary wet cleaners in which most of the remaining flue dust is removed by washing with water, and secondary cleaners such as electrostatic precipitators.

The principal steelmaking methods in use today are the Basic Oxygen Furnace (BOF or BOP), the Open Hearth Furnace, and the Electric Arc Furnace. The steelmaking processes all basically refine the product of the blast furnace blended with scrap or scrap alone, and alloying elements to required analyses for particular purposes. Steel is any alloy of iron containing less than 1.0% carbon. The steelmaking process consists essentially of oxidizing constituents, particularly carbon, down to specified low levels, and then adding various elements to required amounts as determined by the grade of steel to be produced.

The basic raw materials for steelmaking are hot metal or pig iron, steel scrap, limestone, burned lime, dolomite, fluorspar, iron ores, iron-bearing materials such as pellets or mill scale.

The steelmaking processes produce fume, smoke, and waste gases as the unwanted impurities are burned off and the process vaporizes or entrains a portion of the molten steel into the off-gases. Other impurities combine with the slag which floats on the surface of the bath and is separately withdrawn. Wastewater results from the steelmaking processes when wet dust collection systems are used on the furnaces and in the slag handling operations.

Although declining in recent years, 30 percent of the steel produced in the United States is still made in open hearth furnaces. Open hearth furnaces, while similar in design, may vary widely in tonnage capacity. The furnaces found in this country range in capacity from 9 to 545 kkg (10 to 600 ton) per heat.

The steelmaking ingredients (iron, scrap, limestone, alloys, etc.) are charged into the front of the furnace through movable doors. Flame to "cook" the steel is supplied by liquid or gaseous fuel which is ignited by hot air.

The molten steel is tapped from the furnace back when ordered specifications have been obtained. In the standard furnace, this occurs 8-10 hours after the first charge. Many furnaces use oxygen lances which create a more intense heat and reduce charge-to-tap time. The tap-to-tap time for the oxygen-lanced open hearth probably averages about 8 hours, with about 10 hours being the average when oxygen is not used.

The open hearth furnace allows the operator, in effect, to "cook" the steel to required specifications. The nature of the furnace permits him to continually sample the batch content and make necessary additions. The major drawback of the process is the long time required to produce a "heat". Many basic oxygen furnaces can produce eight times the steel of a comparable open hearth over the same period of production time.

Since the introduction in the United States of the more productive basic oxygen process, open hearth production has declined from a peak of 93 million kkg (102 million tons) in 1956 to 32 million kkg (35 million tons) in 1971. The basic oxygen furnace steel production first equaled that from open hearths in 1969. The basic oxygen furnace is now clearly the major steelmaking process.

Vessels for the basic oxygen process are generally vertical cylinders surmounted by a truncated cone. High-purity oxygen is supplied at high pressure through a water-cooled tube mounted above the center of the vessel. Scrap and molten iron are charged to the vessel and a flux is added. The oxygen lance is lowered and oxygen is admitted. A violent reaction occurs immediately and the resultant turbulence brings the molten metal and the hot gases into intimate contact, causing the impurities to burn off quickly. An oxygen blow of 18 to 22 minutes is normally sufficient to refine the metal. Alloy additions are made and the steel is ready to be tapped.

A basic oxygen furnace can produce 180 to 270 kkg (200 to 300 tons) or more of steel per hour and allows very close control of steel quality.

A major advantage of the process is the ability to handle a wide range of raw materials. Scrap may be light or heavy, and the oxide charge may be iron ore, sinter, pellets, or mill scale.

The annual production of steel in the United States by the basic oxygen process has increased from about 545,000 kkg (600,000 tons) in 1957 to 58 million kkg (64 million tons) in 1971. It is anticipated that basic oxygen production will continue to increase at the expense of open hearth production.

The electric-arc furnace is uniquely adapted to the production of high-quality steels; however, most of the production is carbon steel. Practically all stainless steel is produced in electric-arc furnaces. Electric furnaces range up to 9 meters (30 feet) in diameter and produce from 1.8 to 365 kkg (2 to 400 tons) per cycle in 1.5 to 5 hours.

The cycle in electric furnace steelmaking consists of the scrap charge, the meltdown, the hot metal charge, the molten-metal period, the boil, the refining period, and the pour. The required heat is generated by an electric arc passing from the electrodes to the charge in the furnace. The refining process is similar to that of the open hearth, but more precise control is possible in the electric furnace. Use of oxygen in the electric furnace has been common practice for many years.

Electric-arc furnaces are to be found in almost every integrated steel mill. Many mills operate only electric furnaces, using scrap as the raw material. In most "cold shops" the electric-arc furnace is the sole steelmaking process.

The annual production of steel in the electric-arc furnace has increased from about 7.2 million kkg (8 million tons) in 1957 to some 19 million kkg (21 million tons) in 1971. Although electric-arc furnaces have been small in heat capacity as compared to open hearth or basic oxygen furnaces, a trend towards larger furnaces has recently developed. Electric-arc furnaces are the principal steelmaking process utilized by the so-called mini steel plants which have been built since World War II.

SECTION IV

INDUSTRY CATEGORIZATION

An evaluation of the steel making operations was necessary to determine whether or not subcategorization would be required in order to prepare an effluent limitations guideline or guidelines which would be broadly applicable and yet representative and appropriate for the operations and conditions to be controlled. Toward this end an understanding of the operations was required.

Description of Operations to Make Raw Steel

Coke Manufacturing

Coke manufacturing is performed as part of an integrated steel mill's function to supply coke which is a basic raw material for the blast furnace. There are two generally accepted methods for manufacturing coke. These are known as the beehive process (nonrecovery) and the by-product or chemical recovery process.

In the by-product method, air is excluded from the coking chambers, and the necessary heat for distillation is supplied from external combustion of fuel gases in flues located within dividing walls between adjacent ovens. Today the by-product process produces about ninety-nine (99) percent of all metallurgical coke. Economic factors have changed the traditional by-product plant operation. Although coke oven gas still remains as a valuable by-product for internal use, the production of light oils, ammonium sulfate and sodium phenolate are not usually profitable.

In the beehive process, air is admitted to the coking chamber in controlled amounts for the purpose of burning the volatile products distilled from the coal to generate heat for further distillation. The beehive produces only coke and no successful attempts have been made to recover the products of distillation.

Coke Making - By-Product Operation

The desire for a higher quality coke and the economic use of by-products provided the initial impetus in the development of the by-product coke oven.

A by-product coke plant consists essentially of the ovens in which bituminous coal is heated, out of contact with air, to drive off the volatile components. The residue remaining in the ovens is coke; the volatile components are recovered and processed in the by-product plant to produce tar, light oils, and other materials of potential value, including coke oven gas. This process is accomplished in narrow, rectangular, silica brick ovens arranged side by side in groups called batteries. Each coke oven is typically 45 centimeters wide, 4.5 meters high, and 12 meters long (approximately 0.5 x 5 x 13 yards). Heat is applied by burning gas in flues located between the walls of adjacent ovens. About forty (40) percent of the gas produced by the coking process is used to heat the coke ovens. The remaining gas is used as a fuel in other mill operations.

Coal is charged through holes into the tops of the ovens from hopper bottom cars which run on tracks over the top of the battery. During the sixteen (16) to twenty-four (24) hour coking period, the gases and volatile materials distilled from the coal, escape through the ascension pipes on the top of the ovens and pass into the collection main which runs the length of the battery. At the end of the coking period, the doors are removed from each end of an oven and the pushing machine pushes the red hot coke into the quenching car. The quenching car moves to the quenching tower where the coke is cooled by water sprays, and the cooled coke is delivered to handling equipment for subsequent use. Much of the quench water is evaporated in the quench tower. The remainder flows to a settling basin where fine coke particles settle out and are periodically removed. The clarified water is recycled to the quenching tower. The settling basin may overflow if an excess of water is in the system, resulting in a source of wastewater.

In the reduction of coal to coke, the coal volatiles are collected through pipes from each oven into a large gas main running the length of the battery. These hot gases, which are withdrawn from the main under suction by exhausters, are given an initial cooling by spraying with water which lowers the temperature and saturates the gas with water vapor. This water is known as flushing liquor. This initial cooling condenses a large portion of the tar in the raw gas. The condensed tar and flushing liquor mixture flows down the suction main and is conveyed to a decanter tank. The partially cooled gas, still under suction, then passes through primary coolers where the temperature is further reduced by indirect application of cooling water.

The condensate resulting from the cooling is pumped to the decanter and mingled with the tar and flushing liquor from the collecting main. The tar and liquor are separated by gravity, the lighter tar being pumped to storage and a portion of the liquor being recirculated as flushing liquor. The process actually produces water which originates from the moisture in the coal. This excess liquid, called ammonia liquor, is drawn off the decant tank and pumped to storage. The tar contains a large proportion of the coal chemicals produced in the ovens.

The ammonia absorber normally follows the tar extractor, but this will be discussed later in conjunction with the ammonia still and dephenolizers.

Following the ammonia absorber, the gas passes through the final coolers in which water sprays dissolve soluble constituents and flush out the insoluble naphthalene which is condensed at this point. The water flows to the naphthalene sump where the naphthalene is recovered by skimming and then to a cooling tower for recirculation through the final cooler. A properly designed closed recirculation system should have little or no discharged wastewater here, since the cooling tower evaporation balances the moisture condensation from the gas. When other than a closed system is used, final cooler water can be the largest source of contaminated wastewater.

From the final coolers, the gas passes through the gas scrubbers in which the crude light oils are removed by an absorbent generally known as wash oil. The crude light oils contain the materials which are further separated and recovered in the by-product plant. The gas then goes to a gas holder for use in underfiring the coke ovens and a booster pump which sends it to the other mill uses.

Following the gas scrubbers, the light oils are stripped from the wash oil absorbent by steam distillation; the wash oil is cooled and recirculated to the gas scrubbers. The vapors leaving the wash oil still are condensed in the light oil condenser and then flow to the light oil decanter where the light oil and condensed water are separated. Indirect cooling is generally used in the wash oil cooler and light oil condenser and no wastewaters are produced. The water separated from the light oil in the decanter is a major source of wastewater.

Two processes are used in the United States for ammonia recovery. They are referred to as semi-direct and indirect. Approximately eighty-five (85) percent of the ammonia produced in coke plants is recovered as ammonium sulfate by the semi-direct process. The balance is produced as concentrated ammonia liquor by the indirect process.

In the indirect ammonia recovery process, a portion of the ammonia is dissolved in the flushing liquor. Additional ammonia is scrubbed from the gas with water. An ammonia still is used to concentrate the ammonia liquor for sale in this form.

In the semi-direct ammonia recovery process, the ammonia absorber, or saturator, follows the tar extractor. Here the gas passes through a dilute sulfuric acid solution in a closed system from which ammonium sulfate is crystallized and dried for sale.

The ammonia still receives the excess ammonia liquor from which ammonia and other volatile compounds are steam distilled. From the free leg of the ammonia still, ammonia, hydrogen sulfide, carbon dioxide, and hydrogen cyanide are steam distilled and returned to the gas stream. Milk of lime is added to the fixed leg of the ammonia still to decompose ammonium salts; the liberated ammonia is steam distilled and also returned to the gas stream. The ammonia liberated in the ammonia still is recovered from the gas as additional ammonium sulfate in the saturators.

Dephenolizers remove phenol from the ammonia liquor and recover it as sodium phenolate. The two most generally employed methods to accomplish phenol removal are liquid extraction and vapor recirculation.

a. Liquid Extraction

In this method, phenol is extracted from the ammonia liquor with a selected solvent before the liquor goes to the ammonia stills. Benzol or light oil have been found to be good solvents. A substantial part of the phenol is then removed from the solvent by distillation or by extraction with strong caustic solution.

The liquid extraction plant consists of two extraction vessels, one for the removal of phenols from the ammonia liquor, and one for the recovery of phenols from the solvent. Suitable means for providing intimate contact between the solvent and the ammonia liquor is incorporated in the first extractor. The benzol or light oil, carrying the phenol in solution, is then treated in washers with caustic soda to recover the phenol as sodium phenolate. These units are quite efficient, consistently removing and recovering from ninety (90) to ninety-five (95) percent of the phenol from the ammonia liquor.

b. Vapor Recirculation

This process utilizes the vapor pressure of phenol and operates in conjunction with the ammonia still. The ammonia liquor first is distilled in the free leg of the ammonia still in order to remove the maximum quantities of the acidic gases, hydrogen sulfide, carbon dioxide, and hydrogen cyanide, but the minimum amount of phenol.

The ammonia liquor leaving the base of the "free leg" is then transferred to the dephenolizing unit, where the phenols are removed. The dephenolized liquor is returned to the "lime leg".

In the operation of the dephenolizing unit, the liquor is pumped into the top of a dephenolizing tower consisting of two main sections. In the upper section, it passes downward over wood hurdles and meets a countercurrent flow of steam which vaporizes the phenols.

The liquor from the base of the upper section returns to the lime leg of the ammonia still. The phenol vapors and steam are carried into the bottom of the tower and travel upward through steel turnings where they meet a countercurrent flow of caustic soda which extracts the phenols and forms sodium phenolate.

This operation is conducted at 100°C. At this temperature, the equilibrium of the phenol-sodium phenolate reaction is such that a suitable balance between the utilization of sodium hydroxide and the loss of phenol results in the conversion of about fifty (50) percent of the available sodium hydroxide into sodium phenolate with a loss of about five (5) percent of the phenol.

The coke oven gas is sometimes further purified following the light oil scrubbers to remove hydrogen sulfide. The carbonate process is sometimes used to recover elemental sulfur for sale. Some plants employ no ammonia stills or saturators. The Keystone process recovers anhydrous ammonia through absorption in a recycled solution of ammonium phosphate. In a typical absorption cycle, lean forty (40) percent phosphate solution is then reboiled in a distillation tower from which the ammonia vapor is recovered and the lean phosphate solution is separated for reuse. The nature of the Keystone operation is such that additional light oils are recovered from the gas due to the fact that it is cooled and compressed following the conventional light oil scrubbers. The wastewater produced here would presumably be similar to those from the conventional light oil decanter and agitator.

The crude coal tar is usually sold as produced. At some plants, however, the tar is refined using a continuous type distillation unit with multiple columns and reboilers. Ordinarily continuous distillation results in four fractions: light oils, middle or creosote oils, heavy oils, and anthracene oil which are cuts taken at progressively higher temperatures. The light oils are agitated with sulfuric acid and neutralized with caustic soda after the first crude fractionization and then redistilled.

After naphthalene removal, the phenols and other tar acids are extracted from the middle oil fraction with a caustic solution, neutralized and then fractionally distilled. The wastewaters although small in volume when compared with other coke plant waste sources do contain a variety of organic compounds from process water uses in addition to the cooling and condenser water found from distillation processes.

The most significant liquid wastes discharged from the coke plant are excess ammonia liquor (varying from straight flushing liquor to still waste), final cooling water overflow, light oil recovery wastes, and indirect cooling water. In addition, small volumes of water may result from coke wharf drainage, quench water overflow, and coal pile runoff.

The volume of ammonia liquor produced varied from 100 to 200 l/kkg (24 to 48 gal/ton) of coke at plants using the semi-direct ammonia recovery process to 350 to 530 l/kkg (84 to 127 gal/ton) for the indirect process. As indicated above, only a few by-product coke plants utilize the latter process.

Indirect (non-contact) cooling water is not normally considered waste but leaks in coils or tubes may contribute a significant source of pollution.

Gas final cooler water is a potential source of highly toxic cyanogen compounds. Cooling of coke oven gas in the final cooler condenses about 25 liters of water from the gas per kkg (6 gal/ton) of coke produced, in addition to the spray water used in the direct cooling of the gas stream. Flow volume discharged from a well-designed final cooler recirculation system ranges from 40 to 85 l/kkg (10 to 20 gal/ton) of coke produced.

Light oil recovery wastes will vary with the plant process. Condensed steam from the stripping operations and cooling water constitute the bulk of liquid wastes discharged. Flows may vary from 1,800 to 5,000 liters per kkg of coke (430 to 1,200 gal/ton) at plants which discharge cooling water once-through to 150 l/kkg (36 gal/ton) of coke where cooling water is recycled. Effluent from the light oil recovery plant contains primarily phenol, cyanide, ammonia, and oil.

The quenching of coke requires about 1,800 liters of water per kkg of coke (432 gal/ton). Approximately 35 percent of this water is evaporated by the hot coke and discharges from the quench tower as steam. The remainder of the water flows to a settling basin for removal of coke fines. The settled water may be recirculated or in some plants is still permitted to overflow to the sewer. This effluent will contain trace amounts of phenol, cyanides, and solids but temperature is the principal objectionable feature of the settled waste.

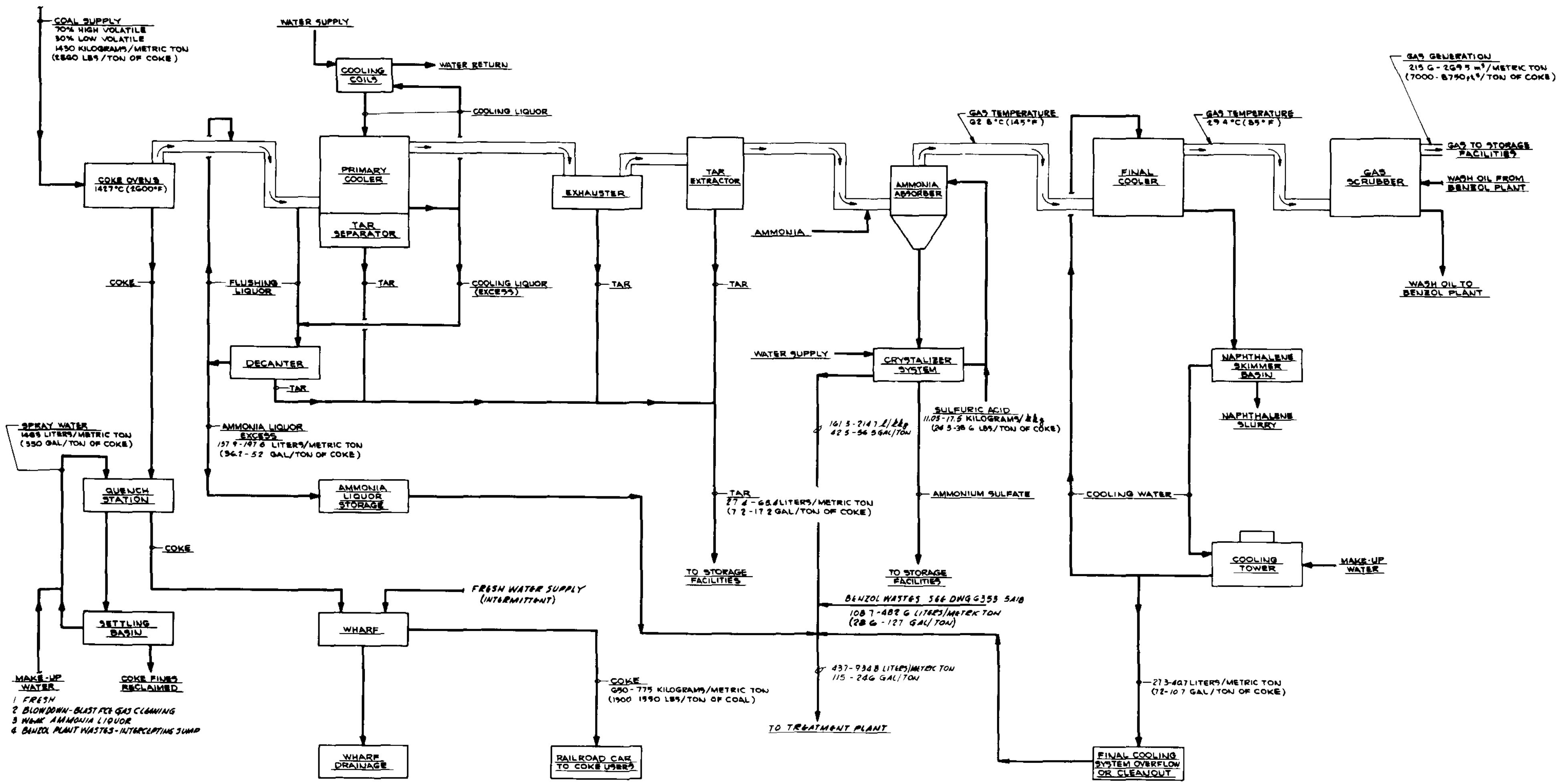
More specific details of the coke plant operations are shown on Figures 2 and 3.

Beehive Coke Subcategory

The name beehive is derived from the fact that the original nonrecovery ovens had an arched roof that closely resembled the typical old fashioned beehive. The ovens are charged as soon as possible after the previous charge is emptied in order to utilize the heat from the previous charge to start the coking process. The oven is charged from above; the coal pile inside the oven must be leveled to insure uniform coking of the coal.

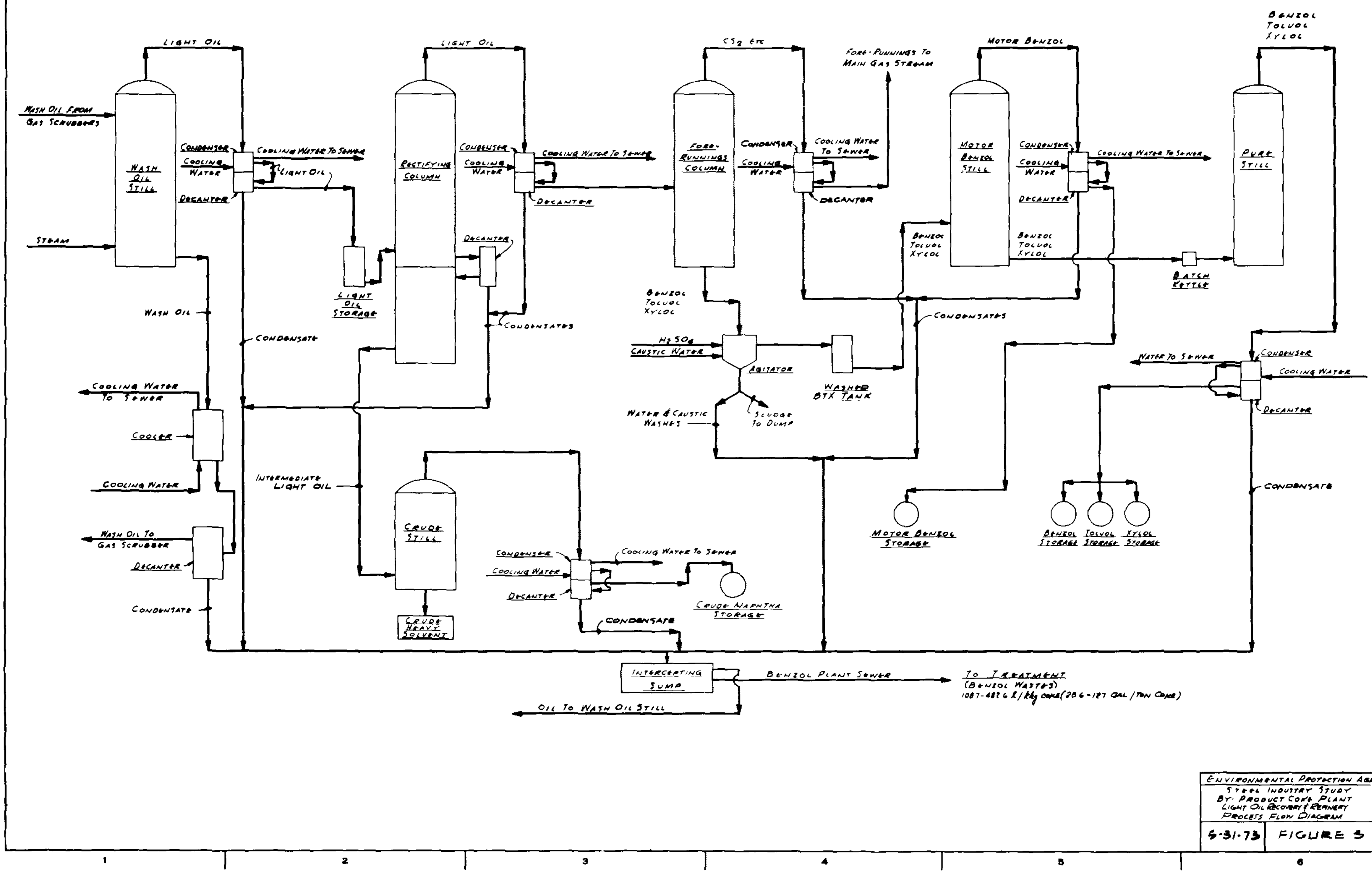
Coking proceeds from the top of the coal downward, so that coking time depends mainly on the depth of the coal. The coking time will vary from 48 to 96 hours depending upon the type of coal charged and type of coke required.

At the end of the coking cycle, the brickwork closing the door is torn out, and the coke is quenched in the oven with water. After quenching, the coke is drawn from the oven. The process is very dirty and



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
BY-PRODUCT RECOVERY
PROCESS FLOW DIAGRAM

3-21-73 FIGURE 2



Environmental Protection Agency
Steel Industry Study
By-Product Coke Plant
Light Oil Recovery & Refinery
Process Flow Diagram

5-31-73 FIGURE 3

generates smoke which discharges to the atmosphere when the brickwork door is removed.

The beehive ovens were popular in the early nineteen hundreds, which was prior to the existence of air pollution regulations. The gases were simply discharged into the atmosphere. The beehive coking industry reached its maximum production in 1916 when more than 31 million kkg (34 million tons) of beehive coke were produced, this being two-thirds (2/3) of the total national coke production. A properly controlled beehive oven will have very little water discharge. If water is not properly regulated, the working area becomes quite sloppy. Therefore, it behooves the operator to regulate the water to insure a good working environment. In some instances, an impoundment lagoon is provided to collect overflow water and settle out coke fines. Discharges from this pond will contain phenol and cyanide.

More specific details of the beehive coke process are shown on Figures 4 and 5.

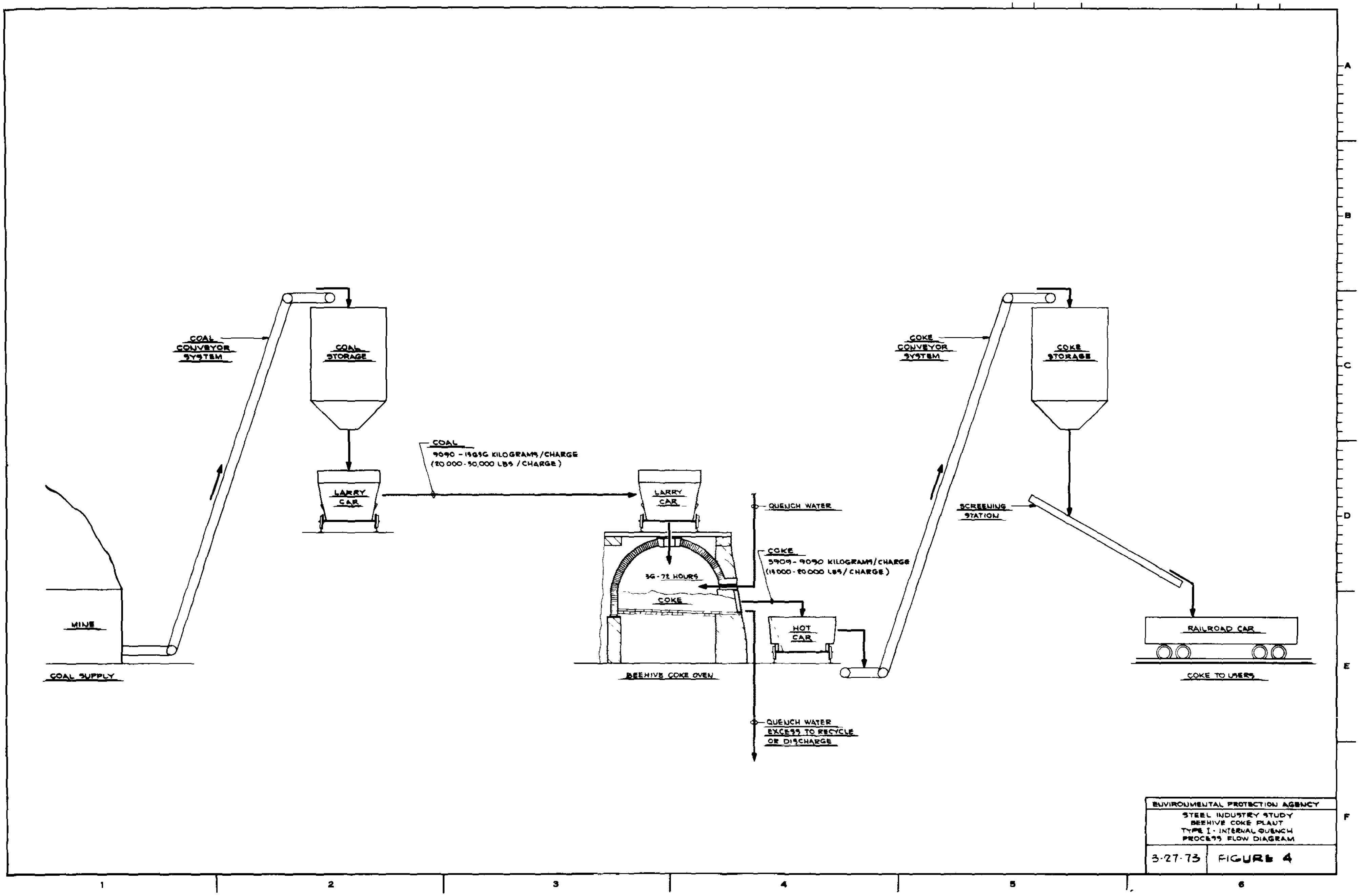
Sintering Subcategory

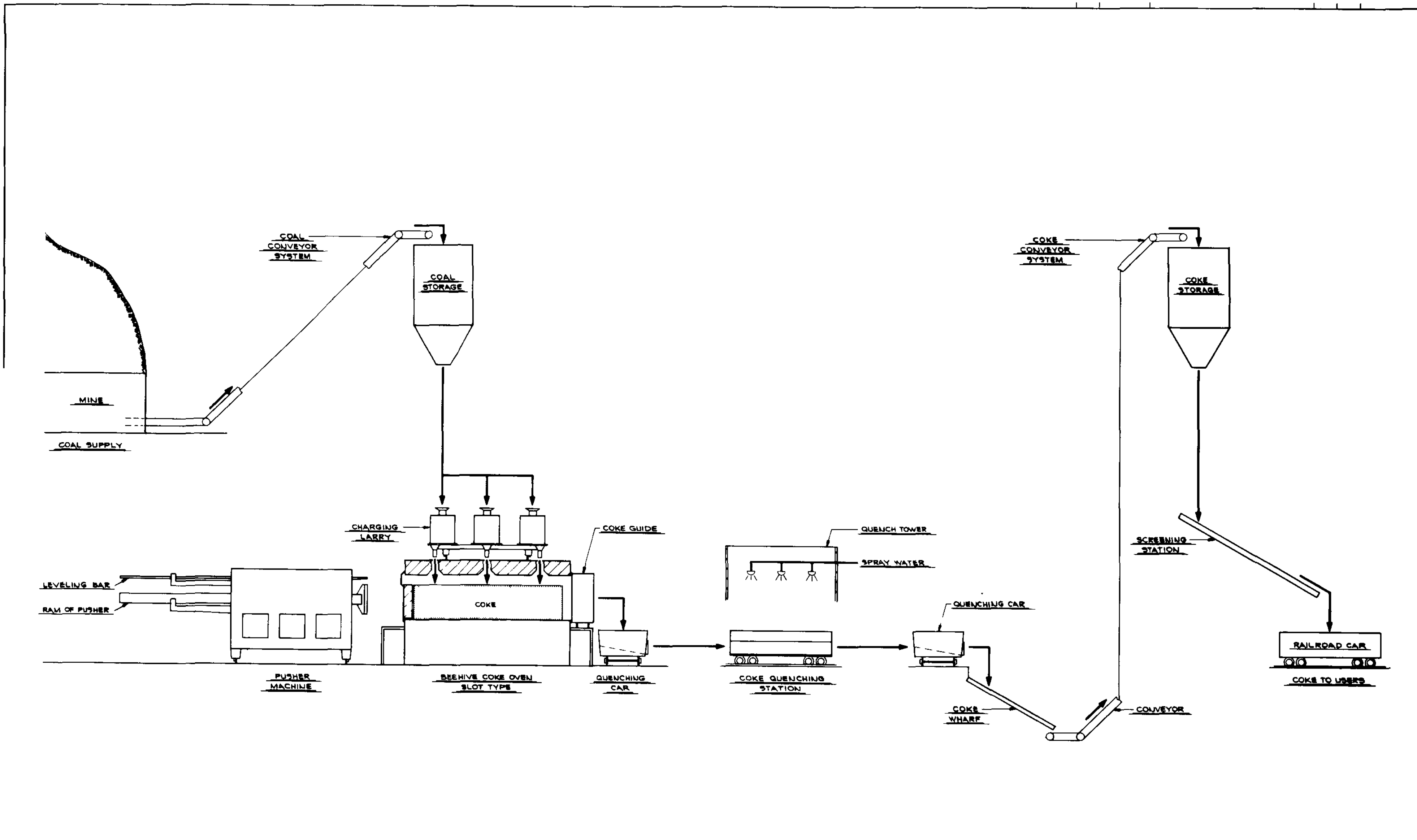
The sintering plant as part of today's integrated steel mill has the primary function of agglomerating and recycling fines back to the blast furnace. Fines, consisting of iron bearing wastes such as mill scale and dust from the basic oxygen furnace, open hearth and blast furnace are blended with fine iron ore and limestone to make an agglomerate for charging to the blast furnace.

The sintering is achieved by blending the various iron bearing components and limestone with coke fines which act as a fuel. The mixture is spread evenly on a moving down draft grate and ignited by a gas fired ignition furnace over the bed. After ignition, the down draft of air keeps the coke burning and as it burns, it quickly brings the bed to fusion temperature. As the bed burns, the carbon dioxide is driven from the limestone, and a large part of the sulfur, chloride and fluoride is driven off with the gases. The oil in the mill scale is vaporized and also removed with the gases.

The hot sinter is crushed as it is discharged from the sinter machine and the crushed sinter is screened before it is air cooled on a sinter cooler. After cooling, the sinter is sized in several size factions. The sizing is necessary to meet the requirements of the blast furnace operators that the feed to the blast furnace be closely sized at any one time. The fines [below 0.6 cm (0.24 in.)] from the screening are recycled to the beginning of the sinter process.

The sinter is very dusty and abrasive; therefore, each transfer must be carefully hooded and dedusted. The submicron sized dust particles which are collected are recycled to the beginning of the process.


COAL CONVEYOR SYSTEM
COAL STORAGE
LARRY CAR
COAL
9090 - 13636 KILOGRAMS/CHARGE
(20,000 - 30,000 LBS / CHARGE)
LARRY CAR
QUENCH WATER
COKE
5909 - 9090 KILOGRAMS/CHARGE
(13,000 - 20,000 LBS / CHARGE)
36 - 72 HOURS
COKE
HOT CAR
COKE CONVEYOR SYSTEM
COKE STORAGE
SCREENING STATION
RAILROAD CAR
MINE
COAL SUPPLY
BEEHIVE COKE OVEN
QUENCH WATER
EXCESS TO RECYCLE OR DISCHARGE
COKE TO USERS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE PLANT
TYPE I - INTERNAL QUENCH
PROCESS FLOW DIAGRAM
3-27-73
FIGURE 4



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE PLANT
TYPE II - EXTERNAL QUENCH
PROCESS FLOW DIAGRAM

3-30-73 FIGURE 5

The areas of pollution in the sintering plant are the material handling dust control equipment, the dust in the process gases and the volatilized gases and oil in the process gases. The sulfur in the process gas comes primarily from the fact that the coke fines have more than twice the sulfur than found in larger coke. The chloride comes from the blast furnace dust whereas the fluoride originates from the fluorspar and the limestone used at the basic oxygen plant.

Some of the sinter plants built in the 1950's were equipped with wet scrubbers, while others were equipped with cyclone type dust collectors. Today's plants are generally equipped with fabric type dust filters to minimize power costs and to avoid the problems inherent in disposing of the scrubber effluents produced by wet dust control systems. A fabric type filter requires about 15-20 cm (6 to 8 in.) water pressure drop to meet emission requirements, while a high energy scrubber would require a minimum of 152 cm (60 in.) water to achieve the same emission standards.

More specific details of the sintering operation are shown on Figures 6,7 and 8.

Pelletizing Operation

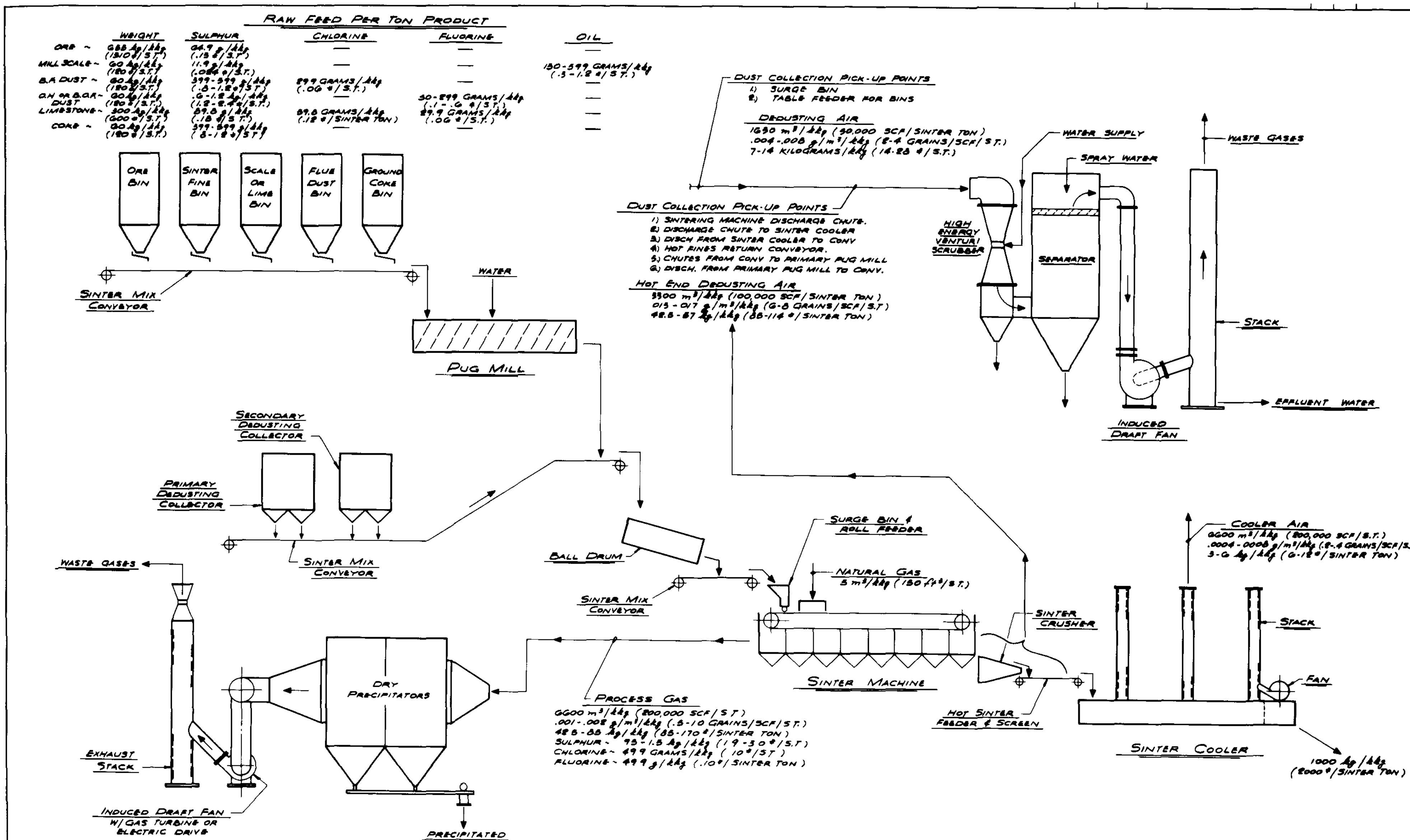
Processing of steel plant wastes takes several forms depending on the specific steel plant and its equipment. These forms can be identified as follows:

1. Disposal - At several electric furnace operations, the dust collected from the furnaces is wetted for ease in handling and to insure that the dust does not cause pollution after it is dumped. This is being done at Babcock & Wilcox Company, Koppel Works.

2. Sinter Plant Feed - The dust from the basic oxygen furnace or electric furnaces is wetted for ease of handling and to insure a better and more permeable sinter mix. This is being done at Bethlehem Steel Company, Bethlehem Works.

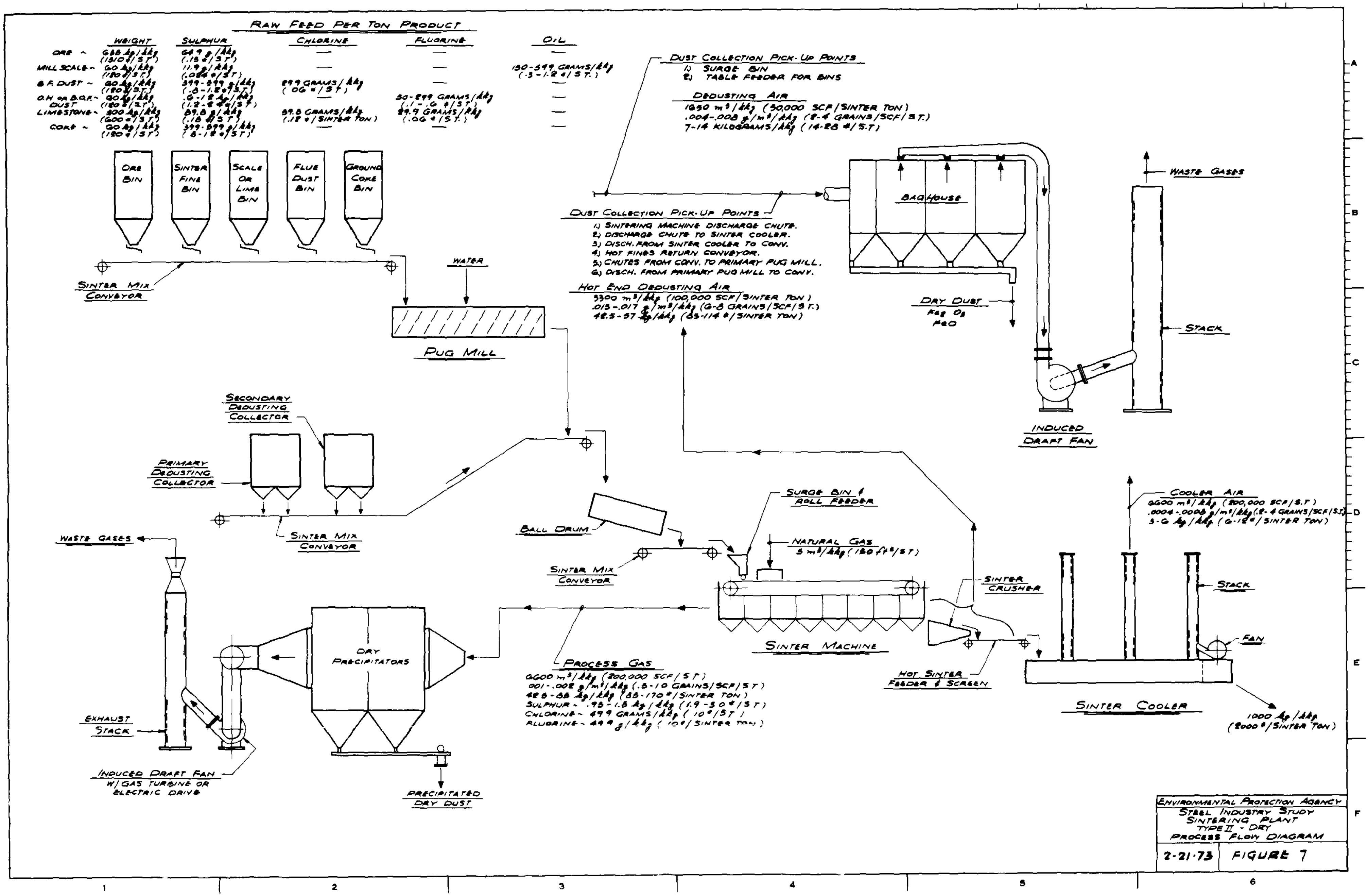
3. Open Hearth Feed - If an open hearth is available, the basic oxygen furnace and open hearth dust may be pelletized and recycled to replace charge ore in the open hearth. A plant to utilize this process is being constructed at Bethlehem Steel Company, Sparrows Point Works.

4. Blast Furnace Feed - All of the fine wastes from steel plants may be recycled to the blast furnace by using a cement binder and curing to insure a calcium silicate bond which will withstand the blast furnace forces. This process has been proven on a pilot scale but no

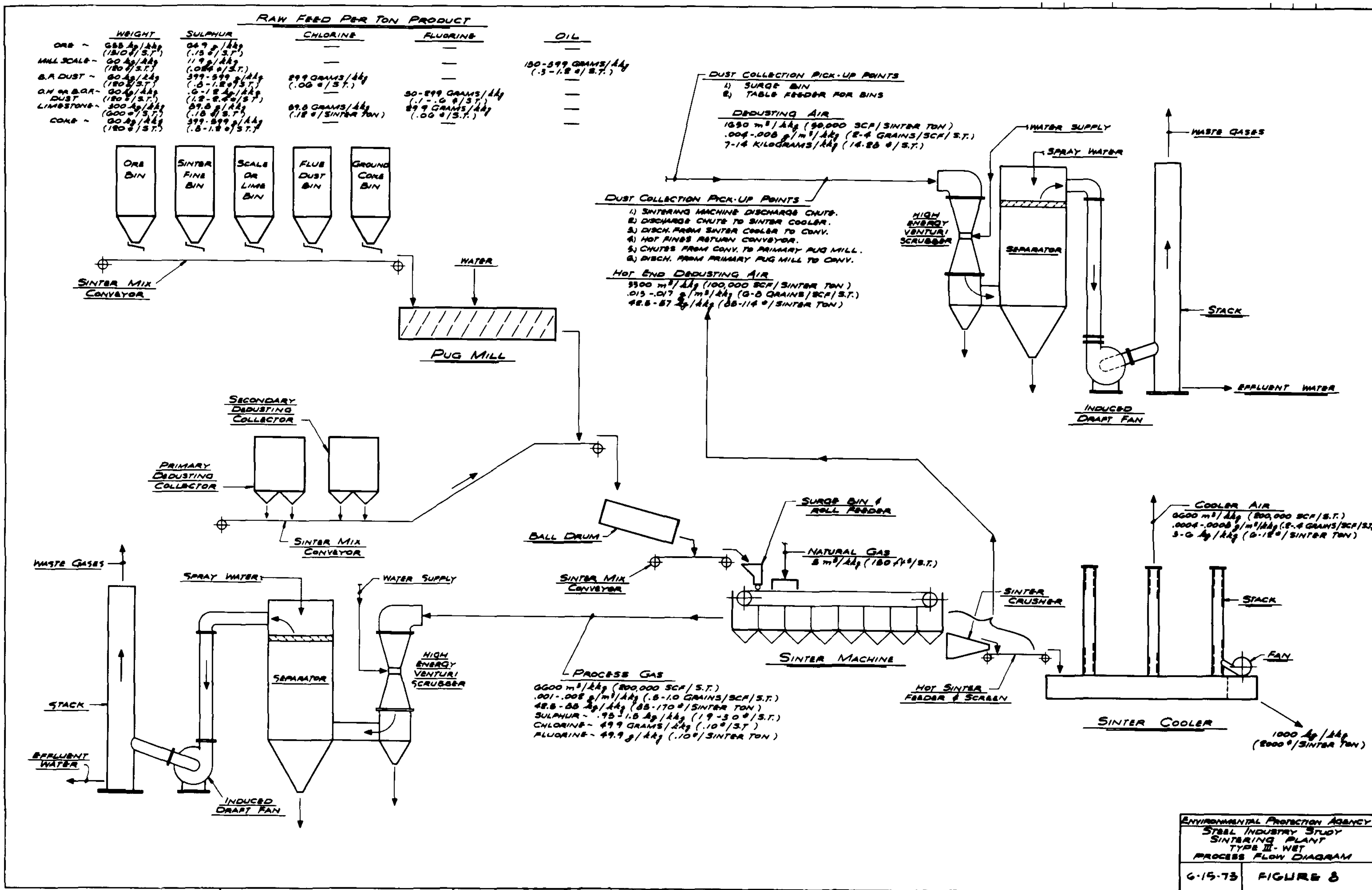


ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
TYPE I - WET
PROCESS FLOW DIAGRAM

2-21-75 FIGURE 6



RAW FEED PER TON PRODUCT
WEIGHT
SULPHUR
CHLORINE
FLUORINE
OIL
ORE ~ 655 kg/kkg (1310#/S.T.) 64.9 g/kkg (.13#/S.T.)
MILL SCALE ~ 60 kg/kkg (120#/S.T.) 11.9 g/kkg (.024#/S.T.) 150-599 GRAMS/kkg (.3-1.2#/S.T.)
B.F. DUST ~ 60 kg/kkg (120#/S.T.) 399-599 g/kkg (.8-1.2#/S.T.) 29.9 GRAMS/kkg (.06#/S.T.)
O.H. OR B.O.F. DUST ~ 60 kg/kkg (120#/S.T.) .6-1.2 kg/kkg (1.2-2.4#/S.T.) 50-299 GRAMS/kkg (.1-.6#/S.T.)
LIMESTONE ~ 300 kg/kkg (600#/S.T.) 89.8 g/kkg (.18#/S.T.) 89.8 GRAMS/kkg (.18#/SINTER TON) 29.9 GRAMS/kkg (.06#/S.T.)
COKE ~ 60 kg/kkg (120#/S.T.) 399-599 g/kkg (.8-1.2#/S.T.)
ORE BIN
SINTER FINE BIN
SCALE OR LIME BIN
FLUE DUST BIN
GROUND COKE BIN
SINTER MIX CONVEYOR
WATER
PUG MILL
DUST COLLECTION PICK-UP POINTS
1.) SURGE BIN
2.) TABLE FEEDER FOR BINS
DEDUSTING AIR
1650 m³/kkg (50,000 SCF/SINTER TON)
.004-.008 g/m³/kkg (2-4 GRAINS/SCF/S.T.)
7-14 KILOGRAMS/kkg (14-28#/S.T.)
DUST COLLECTION PICK-UP POINTS
1.) SINTERING MACHINE DISCHARGE CHUTE.
2.) DISCHARGE CHUTE TO SINTER COOLER.
3.) DISCH. FROM SINTER COOLER TO CONV.
4.) HOT FINES RETURN CONVEYOR.
5.) CHUTES FROM CONV. TO PRIMARY PUG MILL.
6.) DISCH. FROM PRIMARY PUG MILL TO CONV.
HOT END DEDUSTING AIR
3300 m³/kkg (100,000 SCF/SINTER TON)
.013-.017 g/m³/kkg (6-8 GRAINS/SCF/S.T.)
42.5-57 kg/kkg (85-114#/SINTER TON)
BAGHOUSE
DRY DUST
Fe₂O₃
FeO
WASTE GASES
STACK
INDUCED DRAFT FAN
SECONDARY DEDUSTING COLLECTOR
PRIMARY DEDUSTING COLLECTOR
SINTER MIX CONVEYOR
BALL DRUM
SINTER MIX CONVEYOR
SURGE BIN & ROLL FEEDER
NATURAL GAS
3 m³/kkg (180 ft³/S.T.)
SINTER MACHINE
SINTER CRUSHER
HOT SINTER FEEDER & SCREEN
COOLER AIR
6600 m³/kkg (200,000 SCF/S.T.)
.0004-.0008 g/m³/kkg (.2-.4 GRAINS/SCF/S.T.)
3-6 kg/kkg (6-12#/SINTER TON)
STACK
FAN
SINTER COOLER
1000 kg/kkg (2000#/SINTER TON)
WASTE GASES
DRY PRECIPITATORS
PROCESS GAS
6600 m³/kkg (200,000 SCF/S.T.)
.001-.002 g/m³/kkg (.5-1.0 GRAINS/SCF/S.T.)
42.5-85 kg/kkg (85-170#/SINTER TON)
SULPHUR ~ .95-1.5 kg/kkg (1.9-3.0#/S.T.)
CHLORINE ~ 4.99 GRAMS/kkg (.01#/S.T.)
FLUORINE ~ 4.99 g/kkg (.01#/SINTER TON)
EXHAUST STACK
INDUCED DRAFT FAN W/ GAS TURBINE OR ELECTRIC DRIVE
PRECIPITATED DRY DUST
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
TYPE II - DRY
PROCESS FLOW DIAGRAM
2-21-73
FIGURE 7



RAW FEED PER TON PRODUCT
WEIGHT
SULPHUR
CHLORINE
FLUORINE
OIL
ORE BIN
SINTER FINE BIN
SCALE OR LIME BIN
FLUE DUST BIN
GROUND COKE BIN
SINTER MIX CONVEYOR
WATER
PUG MILL
SECONDARY DEDUSTING COLLECTOR
PRIMARY DEDUSTING COLLECTOR
SINTER MIX CONVEYOR
BALL DRUM
SINTER MIX CONVEYOR
SURGE BIN & ROLL FEEDER
NATURAL GAS
SINTER MACHINE
SINTER CRUSHER
HOT SINTER FEEDER & SCREEN
SINTER COOLER
COOLER AIR
STACK
FAN
DUST COLLECTION PICK-UP POINTS
1) SURGE BIN
2) TABLE FEEDER FOR BINS
DEDUSTING AIR
1650 m³/kkg (50,000 SCF/SINTER TON)
.004-.008 g/m³/kkg (2-4 GRAINS/SCF/S.T.)
7-14 KILOGRAMS/kkg (14-28 #/S.T.)
DUST COLLECTION PICK-UP POINTS
1) SINTERING MACHINE DISCHARGE CHUTE.
2) DISCHARGE CHUTE TO SINTER COOLER.
3) DISCH. FROM SINTER COOLER TO CONV.
4) HOT FINES RETURN CONVEYOR.
5) CHUTES FROM CONV. TO PRIMARY PUG MILL.
6) DISCH. FROM PRIMARY PUG MILL TO CONV.
HOT END DEDUSTING AIR
3300 m³/kkg (100,000 SCF/SINTER TON)
.013-.017 g/m³/kkg (6-8 GRAINS/SCF/S.T.)
42.5-57 kg/kkg (85-114 #/SINTER TON)
WATER SUPPLY
SPRAY WATER
HIGH ENERGY VENTURI SCRUBBER
SEPARATOR
INDUCED DRAFT FAN
STACK
WASTE GASES
EFFLUENT WATER
PROCESS GAS
6600 m³/kkg (200,000 SCF/S.T.)
.001-.002 g/m³/kkg (.5-1.0 GRAINS/SCF/S.T.)
42.5-85 kg/kkg (85-170 #/SINTER TON)
SULPHUR ~ .95-1.5 kg/kkg (1.9-3.0 #/S.T.)
CHLORINE ~ 49.9 GRAMS/kkg (.10 #/S.T.)
FLUORINE ~ 49.9 g/kkg (.10 #/SINTER TON)
1000 kg/kkg (2000 #/SINTER TON)
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
TYPE III - WET
PROCESS FLOW DIAGRAM
6-15-73
FIGURE 8

plant is being planned at this time.

Processing plants for disposal, sinter plant feed and open hearth feed are very similar and consist of a feed arrangement from the dust tight bin to a rotating disc. A fine water spray is applied to the dust as it rotates on the disc and as the pellets reach the desired size, they automatically are discharged over the edge. The disc is hooded and vented through a bag type dust collector. The product is discharged into a truck or tote box for removal.

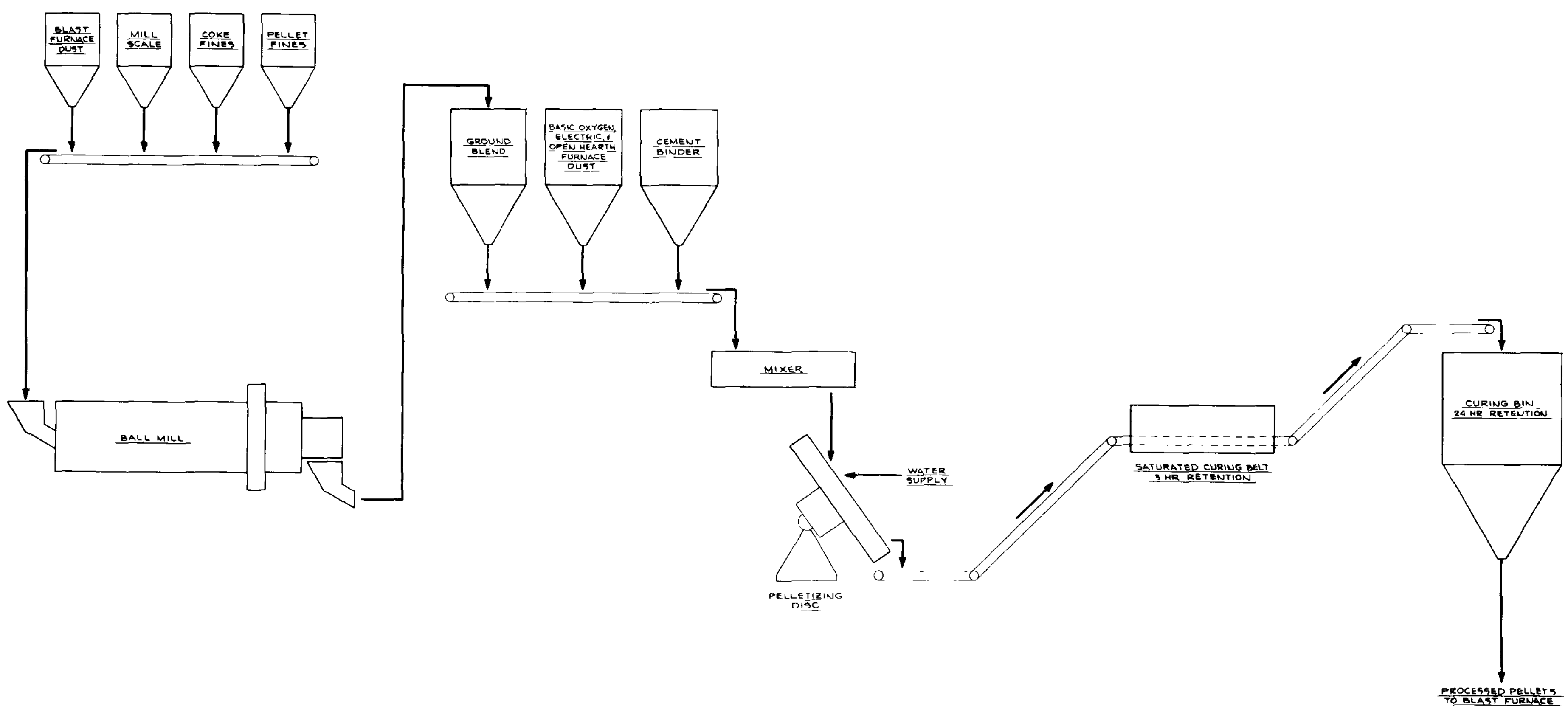
A plant for production of blast furnace feed would consist of a blending and grinding system where the coarser waste material is ground fine enough to pelletize (at least 50% minus 325 mesh). The ground material and fine waste material are blended with a cement binder and the mixture pelletized with a pelletizing disc in a size range from 0.95 to 1.5 cm (0.4 to 0.6 in.). The pellets from the disc are distributed evenly on a curing belt to a depth of about 12 cm. The atmosphere of the curing belt is controlled with the humidity near saturation and the temperature gradually increasing from 20°C to 90°C in approximately three hours. The partially cured pellets are then transferred to a curing bin where they gain final strength in 24 hours. The pellets are screened at 0.6 cm with the fines being recycled through the process. This process virtually eliminates all form of pollution by having no emission except filtered air.

More specific details of the pelletizing process are shown on Figures 9 and 10.

Hot Briquetting Operation

A hot briquetting plant's primary function is to agglomerate steel plant waste material and to make a briquette of sufficient strength to be a satisfactory blast furnace charge. The steel plant wastes may include mill scale, dust from the basic oxygen furnace, open hearth, electric furnace, blast furnace and slag fines from reclamation plants, coke breeze, limestone and pellets. Since hot briquetting plants only process in-plant generated waste, they will be much smaller in size than sintering plants.

The waste will be blended and pelletized to produce a reasonably uniform 1/2 x 1 centimeter diameter pellet for feeding into the fluid bed. The cured pellets are mixed with the hot briquettes from the briquette press and together they pass through a heat exchange drum where the pellets are heated and the briquettes cooled. The heated pellets and cooled briquettes are then separated in a vibrating screen. The preheated pellets are then put into a fluid bed heater where they are heated to approximately 900°C before discharge into the briquetting press. The heat for the fluid bed heater is supplied by the oxidation of the carbon, the iron and the magnetite in the waste material. The discharge temperature is controlled by the amount of fluidizing air added to the

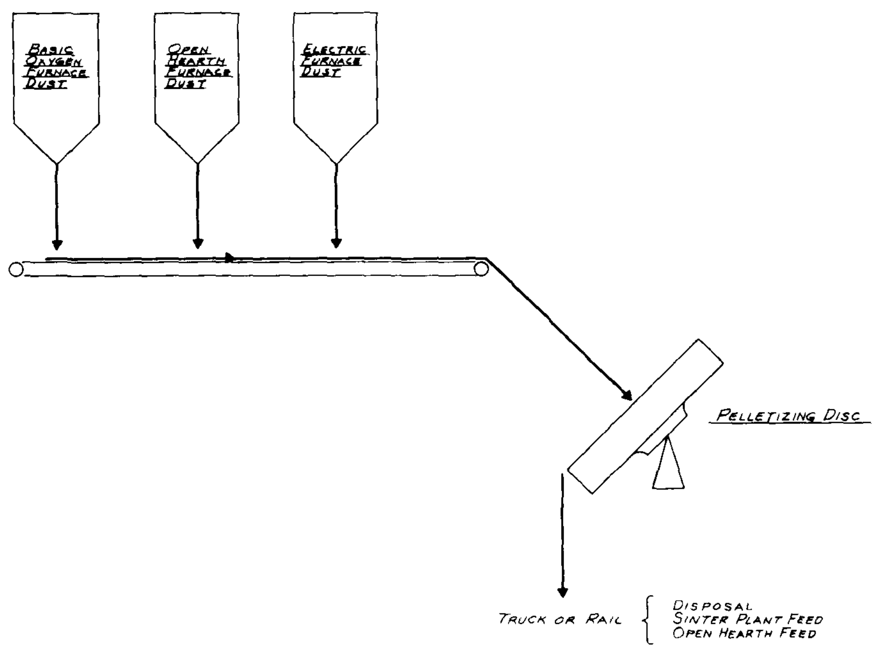


ENVIRONMENTAL PROTECTION AGENCY

STEEL INDUSTRY STUDY
PELLETIZING PLANT
TYPE I - CURBO
PROCESS FLOW DIAGRAM

4-9-73

FIGURE 9



Environmental Protection Agency
Steel Industry Study
Pelletizing Plant
Type II - Uncured
Process Flow Diagram

4-16-73

FIGURE 10

fluid bed. The hot gas cyclone is used to remove the hot dust from the air stream and to return the dust to the bottom of the fluid bed where they are discharged to the briquette press.

One of the advantages of hot briquetting is that for a hot process, the air quantity and temperature are kept to minimum. The maximum temperature of the fluid bed is 980°C while the temperature of the gases from the cyclones is approximately 490°C.

Since only a small amount of coke is consumed to heat the waste the sulphur in the stack gas is very low. At the low temperature of the waste (980°C) very little of the chloride or fluoride in the blast furnace dust and steelmaking dust will be driven off. The oil from the mill scale will be volatilized and combusted in the fluid bed.

The first hot briquetting plant is in the design stage for Republic Steel's South Chicago Plant. It should be completed in late 1974.

More specific details of the briquetting operation are shown on Figure 11.

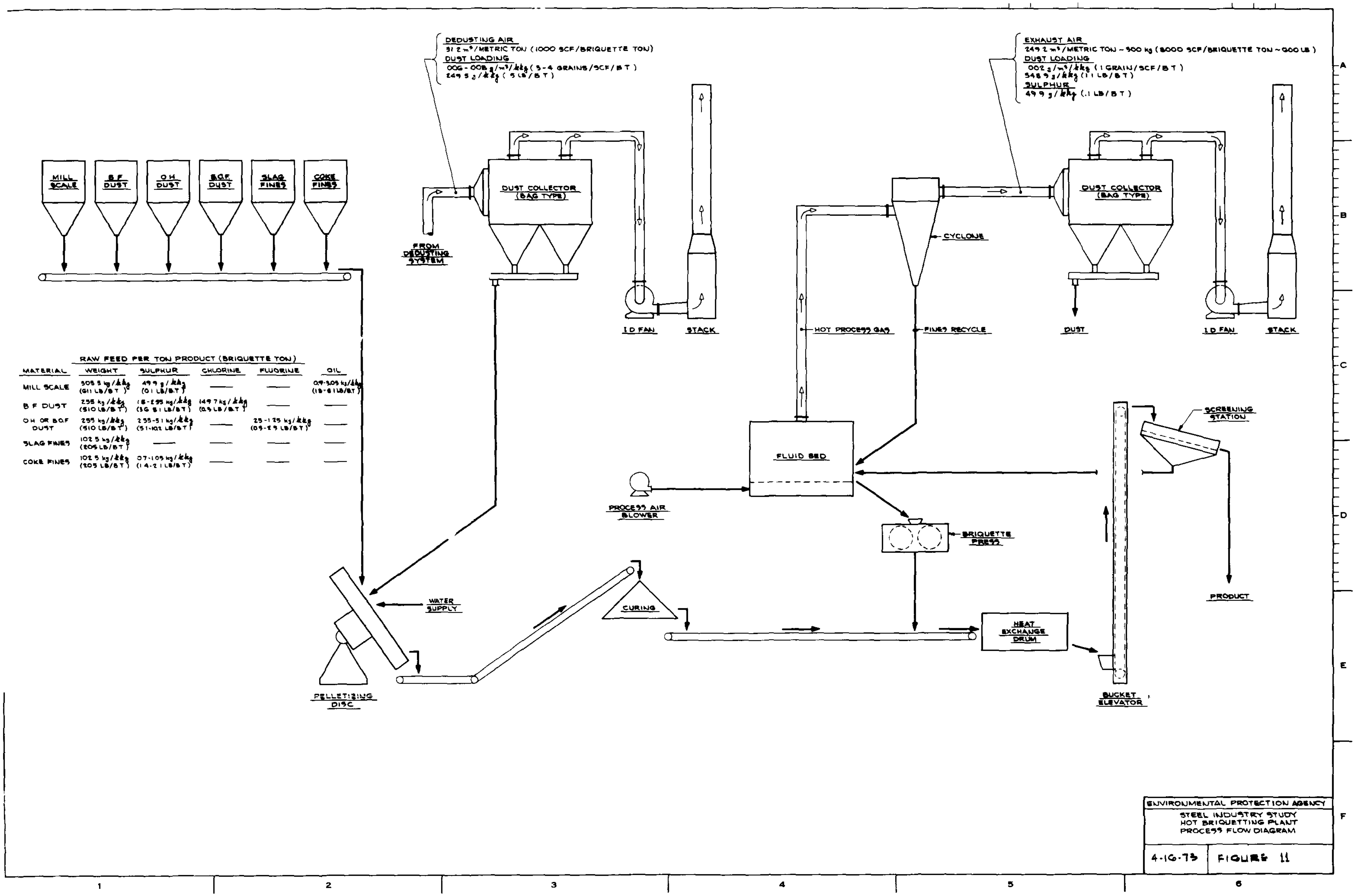
Blast Furnace Operations

Virtually all iron made in the world today is produced in blast furnaces which reduce iron ore (iron oxide) to metallic iron. Iron ore, limestone and coke are charged into the blast furnace. The coke is burned to produce carbon monoxide gas which combines with the ore to produce carbon dioxide gas and metallic iron. The burning coke also supplies the heat to make the reaction proceed and to melt the metallic iron once it is formed.

The solid raw materials are intermittently charged into the top of the furnace. Hot air is blown into the bottom and liquid iron and slag are drawn off from the bottom of the furnace several times each day. Blast furnaces, depending on their size, will produce from a few hundred to in excess of 6,000 kkg (6,600 tons) of iron per day.

The major impurity of most iron ore and coke is silica (silicon dioxide) which has a very high melting point. Removal of this silica is accomplished by the limestone in the furnace. At the high temperature in the furnace, the lime combines with the silica to form a molten mass of a low melting material called slag. The molten slag being lighter than the molten iron, floats on the iron. All the iron leaves the furnace, the floating slag is skimmed off.

There are a great variety of auxiliary operations associated with a blast furnace. These include raw material storage and handling, air compression and heating, gas cleaning, iron and slag handling and dust handling.



RAW FEED PER TON PRODUCT (BRIQUETTE TON)

MATERIAL	WEIGHT	SULPHUR	CHLORINE	FLUORINE	OIL
MILL SCALE	305 5 kg/kkg (611 LB/B T)	49 9 g/kkg (0 1 LB/B T)	—	—	0.9-3.05 kg/kkg (1.8-6 1 LB/B T)
B F DUST	255 kg/kkg (510 LB/B T)	18-25 5 kg/kkg (3.6 5 1 LB/B T)	149 7 kg/kkg (0.3 LB/B T)	—	—
O H OR B.O.F DUST	255 kg/kkg (510 LB/B T)	2 55-5 1 kg/kkg (5 1-10.2 LB/B T)	—	25-1 25 kg/kkg (0.5-2.5 LB/B T)	—
SLAG FINES	102 5 kg/kkg (205 LB/B T)	—	—	—	—
COKE FINES	102 5 kg/kkg (205 LB/B T)	0.7-1.05 kg/kkg (1.4-2 1 LB/B T)	—	—	—

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
HOT BRIQUETTING PLANT
PROCESS FLOW DIAGRAM

4-16-73 FIGURE 11

The raw materials for a blast furnace are normally stored in a large area adjacent to the furnace called the ore yard. The coke is normally delivered directly to the furnace charging system from the railroad cars used to ship the coke out of the coke plant. Several months supply of raw materials are stored in the coke yard.

Approximately 3.5 kkg (3.8 tons) of air are blown through the furnace to make one kkg (1.1 tons) of iron. This air must be compressed to three (3) or four (4) atmospheres and heated to 800°C to 1,000°C before it is injected into the bottom of the furnace. Large steam turbine driven compressors are used for the compression. These turbines may be backpressure, extracting, or condensing in design. If the steam is condensed, large volumes of cooling water are passed through the turbine condensers. The liquid wastes associated with this area would be very similar to those found at utility power generating stations.

After compression, the air is passed through refractory filled vessels called stoves for preheating prior to entering the furnace. Cleaned blast furnace gas is used to preheat the refractory. Two stoves are generally being heated with blast furnace gas while the third stove is preheating the air prior to injection into the furnace. Water is used at the stoves to cool the gas burners and associated equipment.

Because of the high furnace temperatures and the large furnace size, a great deal of cooling water is associated with the operation of a blast furnace. Most plants use once through cooling water, but in some water shortage areas, recirculating cooling systems are used. As a general rule, even in water plentiful areas, some degree of water reuse and recycle is practiced.

The blast furnace proper has a great deal of water cooling associated with it. However, on a blast furnace, the normal temperature rise is very small by comparison to other processes. Rarely is the cooling water temperature rise more than 5°C and frequently it is 1°C or less. In order to conserve water, many plants will take a portion of the cooling water from the furnace and use it in their gas cleaning operations. Other than non-contact cooling water, there should be virtually no wastewater discharges from the furnace proper.

The gases leaving the top of the furnace are hot, dust laden, and traveling at high velocities. The gas consists primarily of a mixture of nitrogen, carbon dioxide, carbon monoxide, and water vapor. In additon to these major components, there are trace amounts of other gases, the most important of which is hydrogen cyanide. This gas is the product of an unwanted reaction of the nitrogen in the air with the hot coke in the furnace. Its concentration is influenced primarily by the temperature of operation. A very hot furnace tends to produce more cyanide than a cooler one. Since the furnace is run on a reducing atmosphere, none of the normal oxides of nitrogen or sulfur are found. Traces of hydrogen sulfide may be present. The gas is explosive and poisonous to the point of fatality on extended exposure mainly because of its carbon monoxide content.

The first step in cleaning the gas so that it can be used as a fuel is to pass it through a settling chamber called a dust catcher to settle out the larger dust particles. This is a dry operation so no liquid wastes result. Following the dust catcher, the gas is normally passed through wet scrubbers and coolers. In some instances, all or part of the gas is also passed through electrostatic precipitators for further cleaning. It is the effluent from the gas scrubbers and coolers that constitute the major portion of the wastewater from the blast furnace operations. After cleaning, the gas is burned in boilers to make steam to drive the compressors and in the stoves to heat the refractory that heats the air going into the furnace.

The water from the gas cleaning operations is normally run to thickeners where the settleable solid are removed. The sludge from the thickeners is filtered and the recovered filter cake along with other fine iron oxide particles, are sent to the sinter plant for agglomeration so that they can be reused in the furnaces. The water removed from the sludge in the filter is returned to the thickener.

A certain amount of phenol and nitrogen compounds are in the coke delivered to the blast furnaces. The concentrations of these materials in the coke are much higher if the coke has been quenched at the coke plant with one of the coke plant waste streams. These compounds evaporate from the coke in the top of the furnace and come out of the furnace with the top gas. A certain portion of them are transferred to the water in the gas scrubbers.

There are two common processes for handling the slag which is drawn off a furnace. These are air cooling and slag granulation. In the granulation process, slag is usually run into a pit of water adjacent to the furnace. High pressure streams of water disassociate the column of liquid slag as it falls into the pit. This rapid, unrestricted cooling causes the slag to expand and crack into small particles that resemble brown sand. This process generates a great deal of steam which passes off into the atmosphere with a slight odor of hydrogen sulfide. Granulated slag is lighter than sand and some of the particles tend to float. The use of this process has declined in recent years to some extent because of the difficulty of keeping the floating slag particles out of the receiving waterways and the problems of air pollution caused by the steam plume.

In the air cooled slag process, the molten slag is poured into dry pits in the ground for slow cooling. A limited amount of water is sprayed on the hot slag to accelerate the cooling. The slag slowly solidifies into one solid mass in the pit and is dug out with a power shovel. Most of the water sprayed on the hot slag evaporates, but if the sprays are not properly controlled, excess water is used and it drains from the pit as a contaminated liquid. The composition of the overflow from the slag granulating operation and the drainage from the air cooling pits will be similar except for concentration. The granulated effluent will be much more dilute. The effluents from slag operations will contain reduced compounds, normally sulfides.

Large volumes of water are required to operate a blast furnace and its associated equipment. A major portion of the water is used for the non-contact cooling of the blast furnace hearth and shell, the stove burners and to condense the steam used to drive the air compressors. This water increases approximately 1-5°C in temperature; otherwise it is discharged in essentially its original state.

A lesser portion of the water is used for contact cooling the blast furnace gas and slag quenching as well as for blast furnace gas cleaning. These waters contain settleable solids and traces of various chemicals contained in the blast furnace gas stream and the slag. The blast furnace gas scrubbing water represents the major portion of the wastewater from the blast furnace area.

More specific details of the blast furnace operation are shown on Figures 12, 13, 14 and 15.

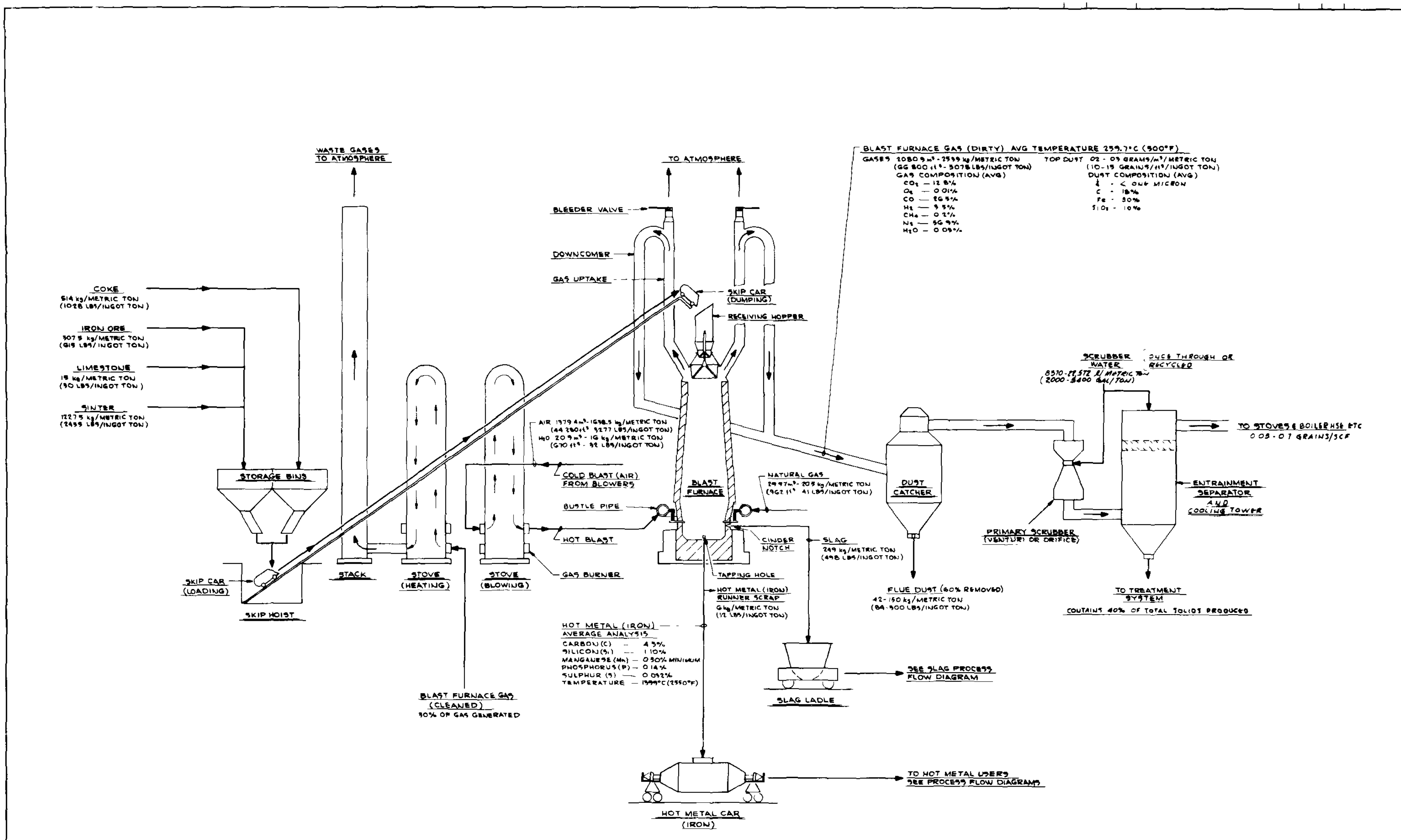
Steelmaking Operations

There are three primary methods in use today for the production of steel, the electric arc furnace, the open hearth furnace and the basic oxygen furnace.

The newest method, the basic oxygen furnace, was introduced in the early fifties and is now rapidly replacing the older open hearth practice. In 1972 the basic oxygen process accounted for 56% of steel production, the open hearth 26.3%, and the electric arc furnace 17.7%.

Each method generally uses the same type of basic raw materials to produce the steel and also results in generally the same waste products such as slag (fluxes), smoke, fume and waste gases.

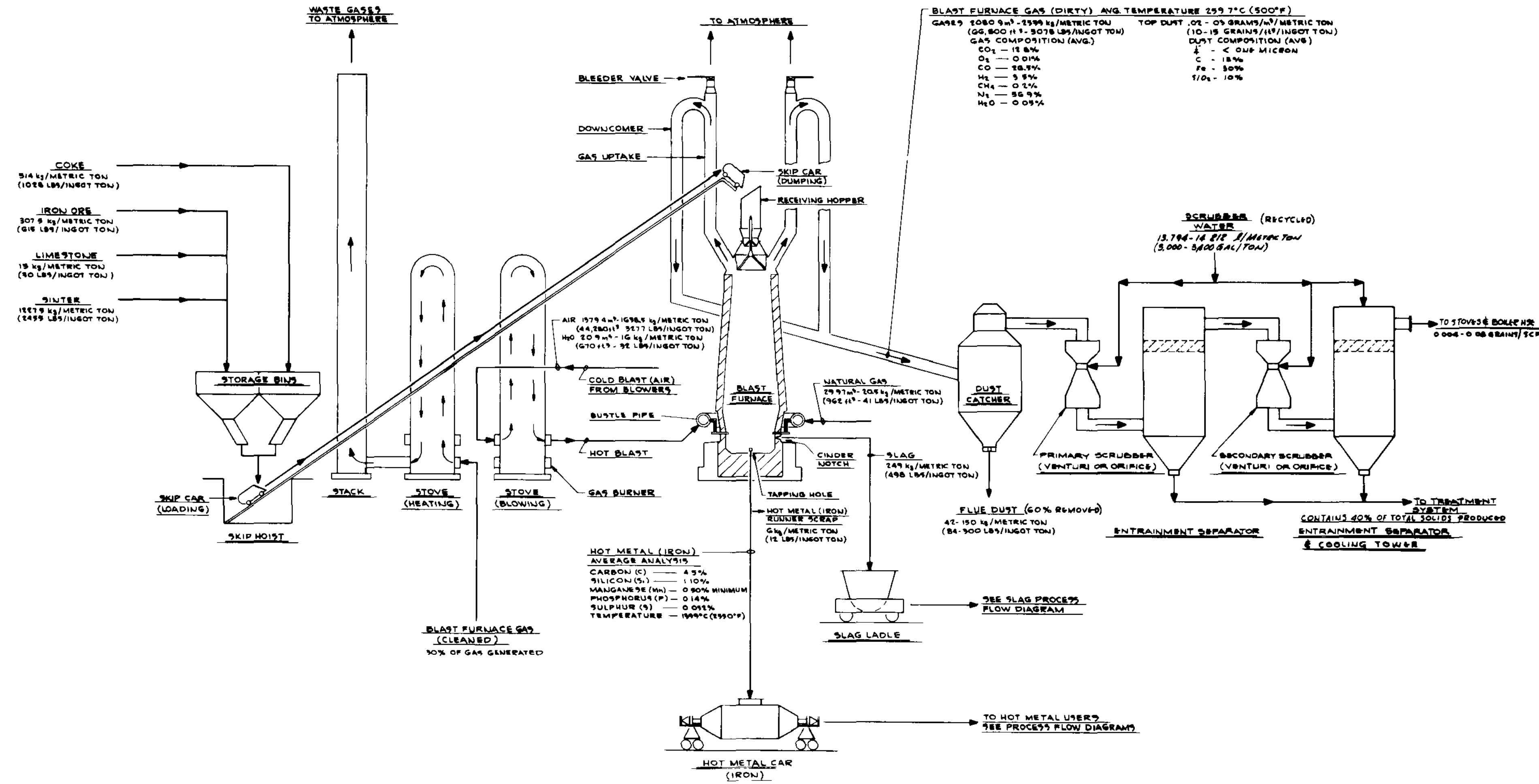
The basic raw materials for the manufacture of steel are hot metal (iron), scrap steel, limestone, burnt lime (CaO), fluorspar (CaF_2), dolomite ($MgCO_3$ and $CaCO_3$) and iron ores (oxides or iron). Other iron bearing materials such as pellets and mill scale are used when available. Alloying materials such as ferro manganese, ferro silicon, etc., are used to finish the steel composition to required specifications. These are added to the steel ladle and sometimes directly in the furnace steel bath. The raw materials are shipped, railroaded or trucked into the plant and are unloaded by means of chutes and conveyor systems into storage bins. In some plants, they are unloaded at an unloading station and mill cranes or special cars, charge the raw materials into the furnaces.



ENVIRONMENTAL PROTECTION AGENCY

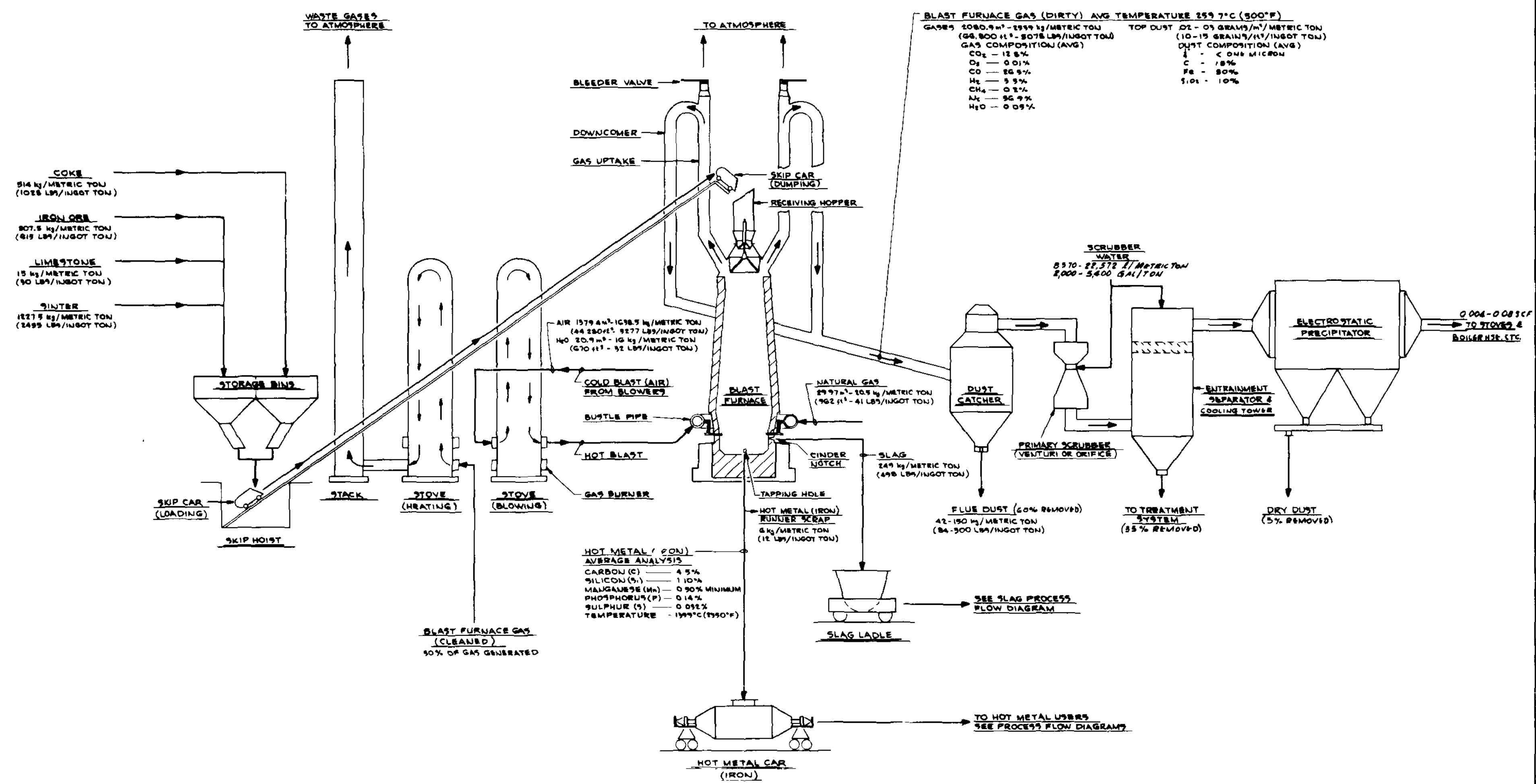
STEEL INDUSTRY STUDY
BLAST FURNACE:
TYPE I - PRIMARY WET SCRUBBER
PROCESS FLOW DIAGRAM

3-19-73 FIGURE 12



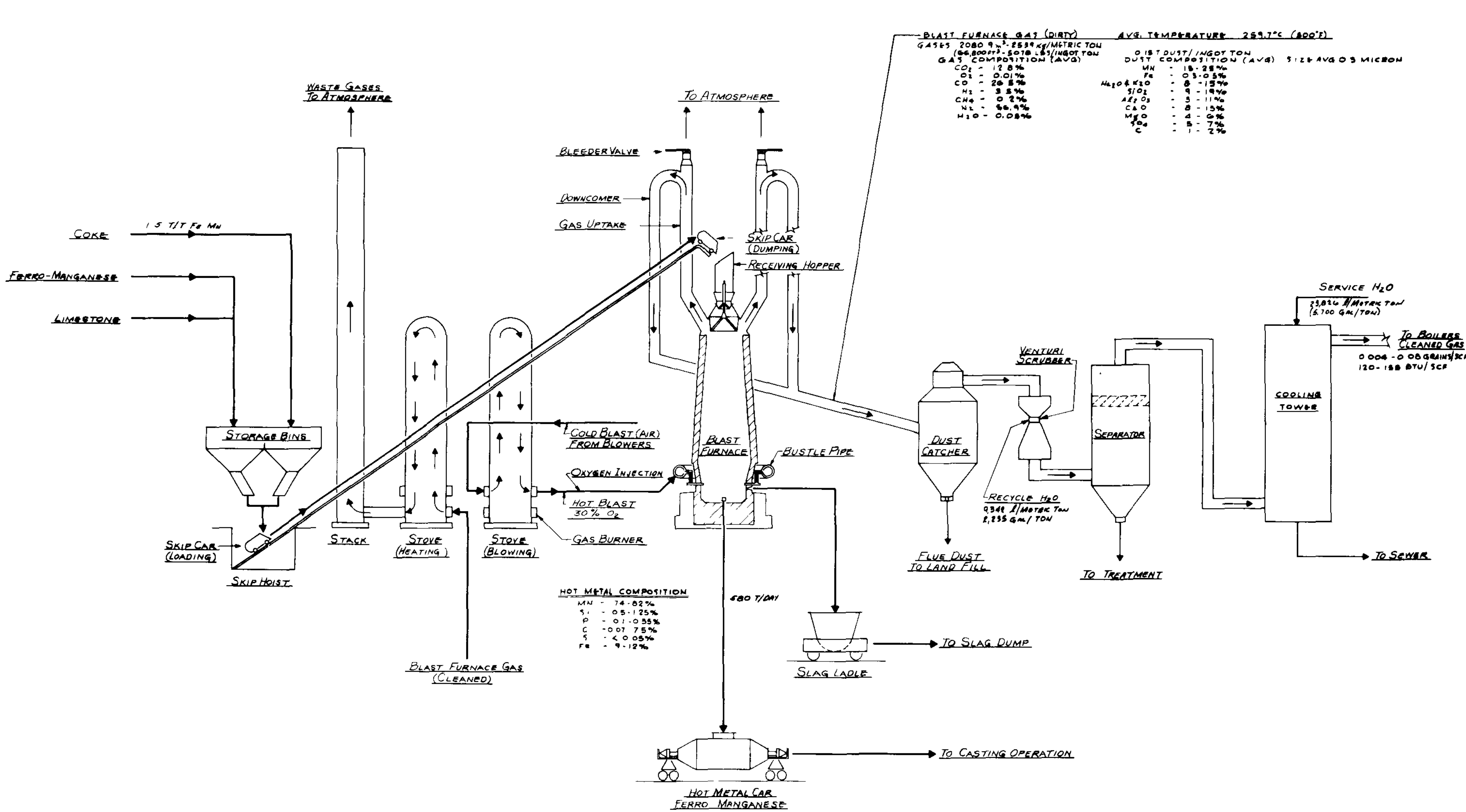
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
TYPE II - PRIMARY & SECONDARY WET SCRUBBER
PROCESS FLOW DIAGRAM

3-20-73 FIGURE 13



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
TYPE III - PRIMARY WET W/DRY SECONDARY
PROCESS FLOW DIAGRAM

3-23-73 FIGURE 14



Environmental Protection Agency
Steel Industry Study
Ferro-Manganese Blast Furnace
Type I - Primary Wet Scrubber
Process Flow Diagram

4-9-73 | FIGURE 15

The waste products derived from the material handling systems are generally airborne contaminants of dust, fumes, and smoke and do not become waterborne until some type of wet dust collector system is utilized.

All three furnace methods use pure oxygen and/or air to refine the hot metal (iron) and other metallics into steel by oxidizing and removing the elements present such as silicon, phosphorus, manganese and carbon. Certain oxides such as silicon dioxide, manganese oxide, phosphorus pentoxide and iron oxide are fluidized in the slag which floats on the metal surface while oxides of carbon are emitted as gases.

Basic Oxygen Furnace Operation

The basic oxygen furnace steelmaking process is a method of producing steel in a pear shaped refractory lined open mouth furnace with a mixture of hot metal, scrap and fluxes. Pure oxygen is injected at supersonic velocities through water cooled copper tipped steel lance for approximately 20 minutes with a total tap-to-tap cycle of approximately 45 minutes. As this process is exothermic (heat generating), a definite percentage of steel scrap can be melted without use of external fuel requirements. The general ratio is about 70% hot metal and 30% scrap. The furnace is supported on trunnions mounted in bearings and is rotated for tapping (pouring) of steel ladles and dumping the slag.

The waste products from this process are heat, airborne fluxes, slag, carbon monoxide and dioxide gases and oxides of iron (FeO, Fe_2O_3, Fe_3O_4) emitted as submicron dust. Also when the hot metal (iron) is poured into ladles or the furnace, submicron iron oxide fume is released and some of the carbon in the iron will precipitate out as graphite, commonly called kish. All of these contaminants become airborne. Fumes and smoke are again released when the steel is poured into steel holding (teeming) ladles from the furnace. Approximately 2% of the ingot steel production is ejected as dust.

The basic oxygen furnaces are always equipped with some type of gas cleaning systems for containing and cooling the huge volumes of hot gases (1,650°C) and submicron fume released.

Water is always used to quench the off-gases to temperatures where the gas cleaning equipment can effectively handle them. Two main process types of gas cleaning systems are used for the basic oxygen furnace, precipitators and venturi scrubbers, but in each case the hot gases are quenched to a lower temperature. In the venturi scrubbers, the gases are quenched and saturated to 80°C whereas for the precipitators the gases are cooled to approximately 250°C.

As the main gas constituent released from the process is carbon monoxide, it will burn outside of the furnace if allowed to come in contact with air.

The major gas cleaning systems in use today, purposely furnish air for burning of this gas. An open hood just above the furnace mouth is provided for the burning, and conveying of gases and fumes to the gas cleaning system. The hoods themselves are made in several different geometric configurations (round, square, octagonal) and are either water cooled or are waste heat steam generating boilers. A special type of wet venturi scrubber and hood is sometimes used where the hood clamps tightly over the furnace mouth and prevents the carbon monoxide gas from burning. The gas is then either collected for fuel or burned at the stack outlet.

If venturi scrubbers are used, the majority of the airborne contaminants are mixed with water and discharged as an effluent. Generally, water clarification equipment is provided for treatment of this effluent.

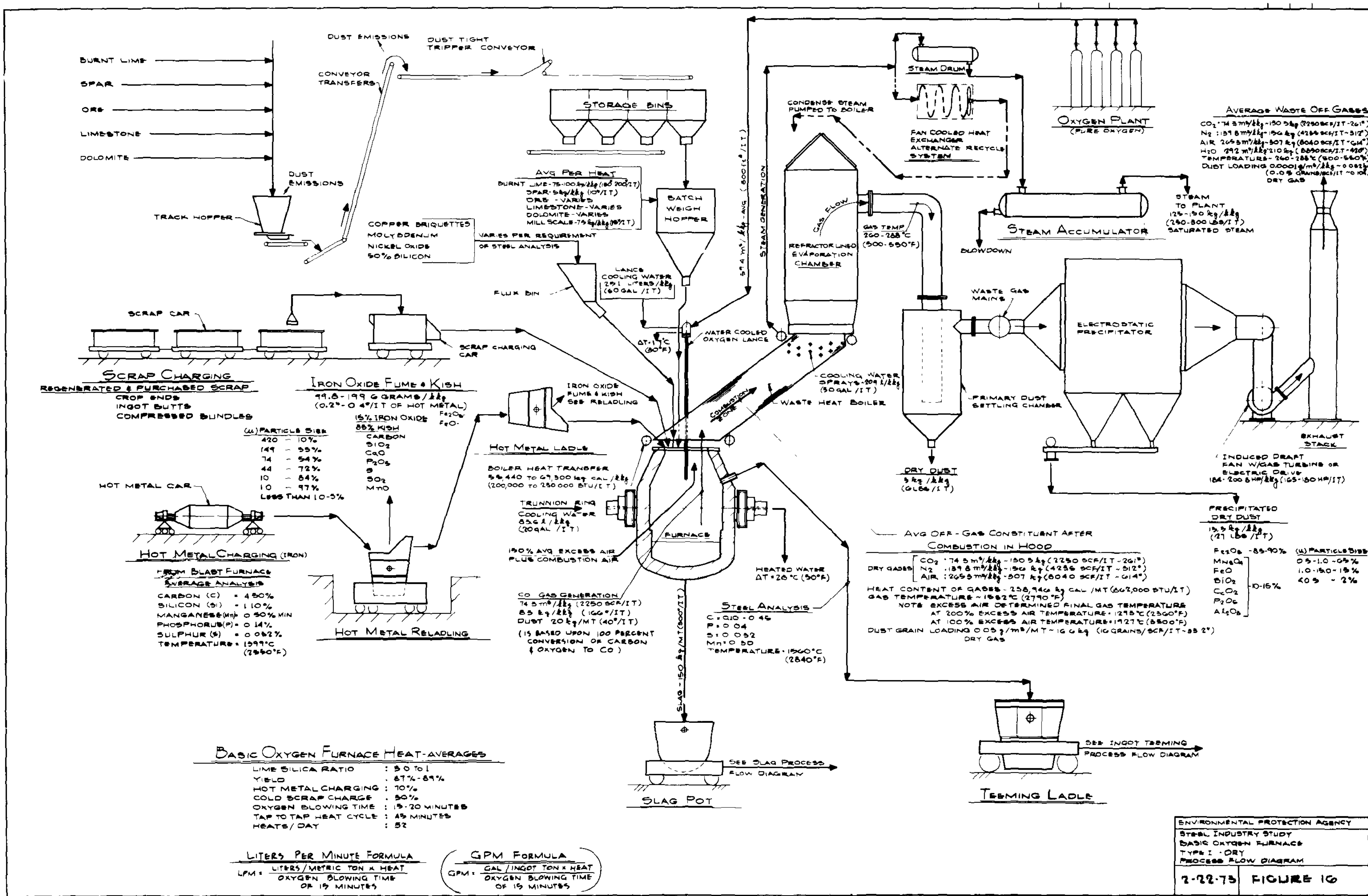
In the case of precipitators, two approaches are used for quenching (cooling) the gases. One is to have an exact heat balance between water required and gas cooling; no effluent is discharged in this case as all of the water is evaporated. The other approach is to pass the gas through a water spray thus oversupplying the water which is discharged as an effluent. This is commonly referred to as a spark box chamber whereas the other is an evaporation chamber.

More specific details of the basic oxygen furnace are shown on Figures 16 through 20.

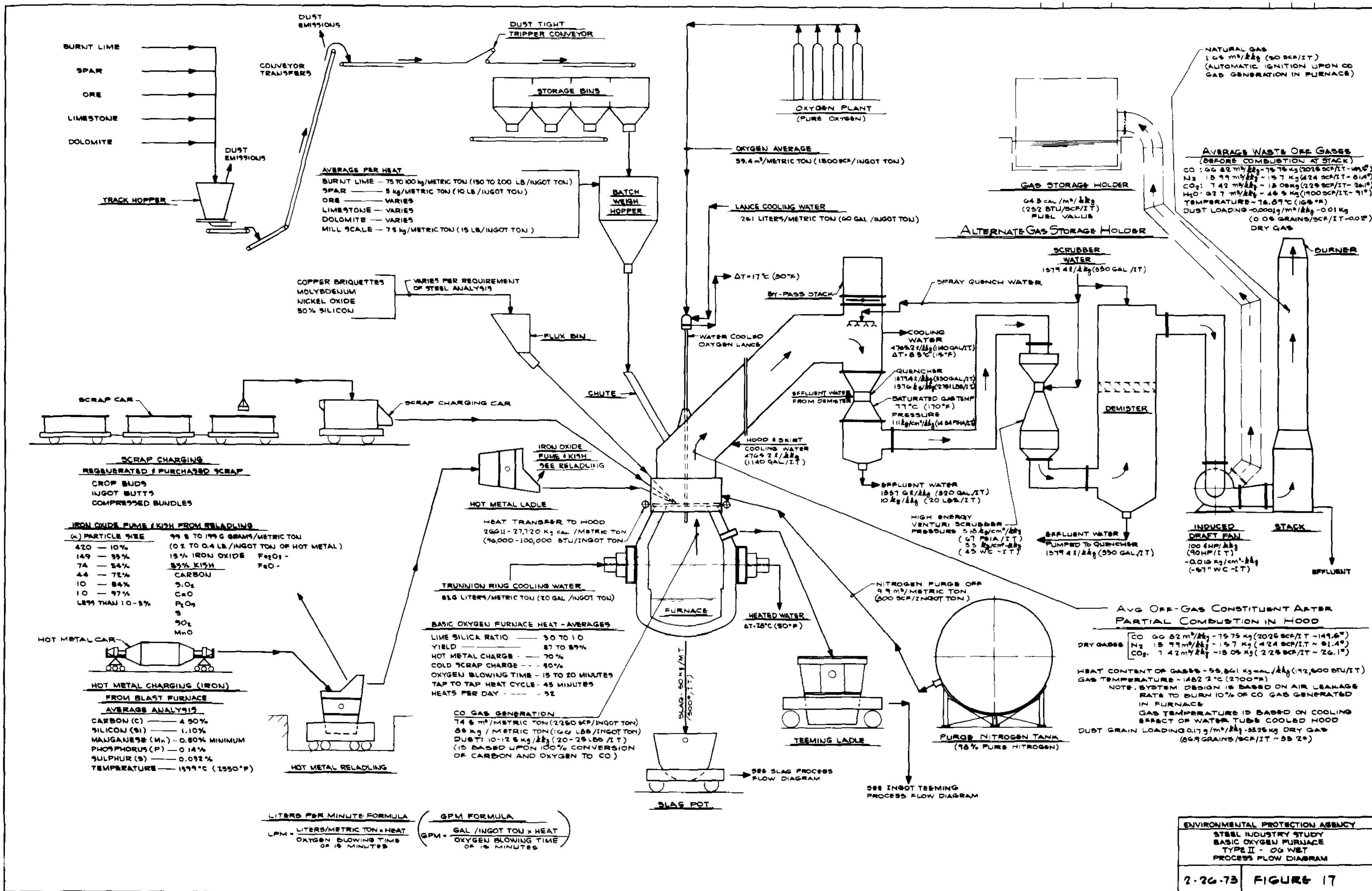
Open Hearth Furnace Operation

The open hearth furnace steelmaking process is an older method of producing steel in a shallow rectangular refractory basin or hearth enclosed by refractory lined walls and roof. The furnace front wall is provided with water cooled lined doors for the means of charging raw materails into the furnace. A plugged tap hole at the base of the wall opposite to the doors is provided to drain the finished molted steel into ladles. Open hearth furnaces can utilize an all-scrap steel charge but generally are used with a 50-50 charge of hot metal and steel scrap.

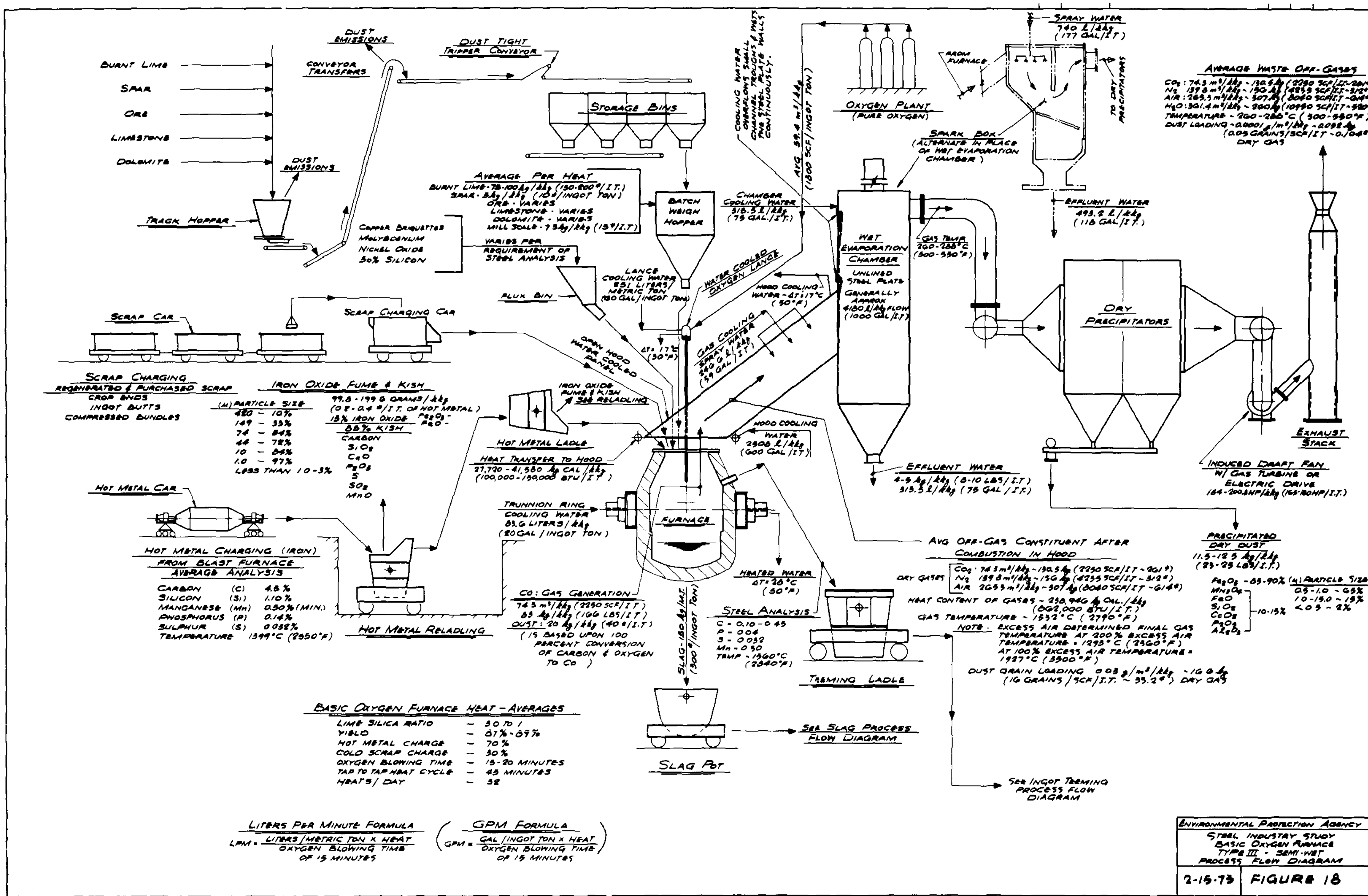
Fuel in the form of oil, coke oven gas, natural gas, pitch, creosote, tar, etc., is burned at one end of the hearth to provide heat for melting of scrap and other process requirements and the type of fuel utilized depends upon the plant economics and fuel availability. The hot gases from refining process and combustion of fuel travels the length of hearth above the raw materials charge and is conducted into a flue downward to a regenerator brick chamber called checkerwork or checkers. These brick masses absorb heat and cool the waste gases to 650-750°C. The combustion system burners, checkers and flues are duplicated at each end of furnace, which permits frequent and systematic reversal of flows, flue gases and preheated air for combustion.



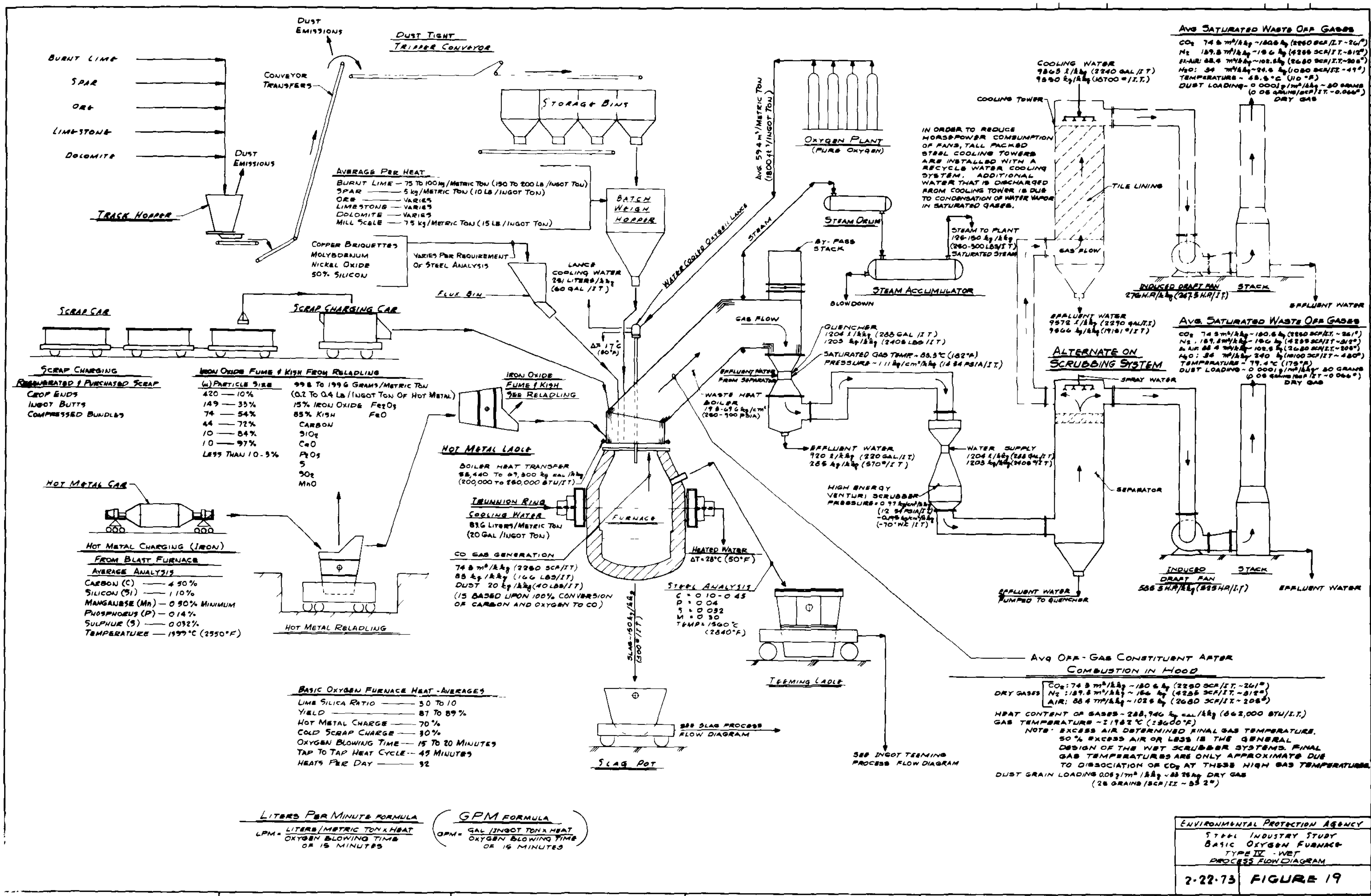
BURNT LIME
SPAR
ORE
LIMESTONE
DOLOMITE
TRACK HOPPER
DUST EMISSIONS
CONVEYOR TRANSFERS
DUST EMISSIONS
DUST TIGHT TRIPPER CONVEYOR
STORAGE BINS
BATCH WEIGH HOPPER
AVG PER HEAT
COPPER BRIQUETTES
MOLYBDENUM
NICKEL OXIDE
50% SILICON
VARIES PER REQUIREMENT OF STEEL ANALYSIS
FLUX BIN
LANCE COOLING WATER
WATER COOLED OXYGEN LANCE
STEAM GENERATION
CONDENSE STEAM PUMPED TO BOILER
STEAM DRUM
FAN COOLED HEAT EXCHANGER ALTERNATE RECYCLE SYSTEM
OXYGEN PLANT
(PURE OXYGEN)
STEAM ACCUMULATOR
BLOWDOWN
STEAM TO PLANT
SATURATED STEAM
AVERAGE WASTE OFF GASES
DRY GAS
GAS FLOW
REFRACTOR LINED EVAPORATION CHAMBER
GAS TEMP 260-288°C (500-550°F)
WASTE GAS MAINS
ELECTROSTATIC PRECIPITATOR
PRIMARY DUST SETTLING CHAMBER
EXHAUST STACK
INDUCED DRAFT FAN W/GAS TURBINE OR ELECTRIC DRIVE
COOLING WATER SPRAYS
WASTE HEAT BOILER
COMBUSTION ZONE
DRY DUST
PRECIPITATED DRY DUST
SCRAP CAR
SCRAP CHARGING CAR
SCRAP CHARGING
REGENERATED & PURCHASED SCRAP
CROP ENDS
INGOT BUTTS
COMPRESSED BUNDLES
IRON OXIDE FUME & KISH
15% IRON OXIDE
85% KISH
IRON OXIDE FUME & KISH SEE RELADLING
HOT METAL LADLE
BOILER HEAT TRANSFER
TRUNNION RING COOLING WATER
150% AVG EXCESS AIR PLUS COMBUSTION AIR
FURNACE
HEATED WATER ΔT=28°C (50°F)
HOT METAL CAR
HOT METAL CHARGING (IRON)
FROM BLAST FURNACE
AVERAGE ANALYSIS
HOT METAL RELADLING
CO GAS GENERATION
(IS BASED UPON 100 PERCENT CONVERSION OF CARBON & OXYGEN TO CO)
STEEL ANALYSIS
AVG OFF-GAS CONSTITUENT AFTER COMBUSTION IN HOOD
SEE SLAG PROCESS FLOW DIAGRAM
SLAG POT
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
TEEMING LADLE
BASIC OXYGEN FURNACE HEAT-AVERAGES
LIME SILICA RATIO : 3.0 TO 1
YIELD : 87%-89%
HOT METAL CHARGING : 70%
COLD SCRAP CHARGE : 30%
OXYGEN BLOWING TIME : 15-20 MINUTES
TAP TO TAP HEAT CYCLE : 45 MINUTES
HEATS/DAY : 32
LITERS PER MINUTE FORMULA
LPM = LITERS/METRIC TON x HEAT / OXYGEN BLOWING TIME OF 15 MINUTES
GPM FORMULA
GPM = GAL/INGOT TON x HEAT / OXYGEN BLOWING TIME OF 15 MINUTES
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
TYPE I - DRY
PROCESS FLOW DIAGRAM
2-22-73
FIGURE 16

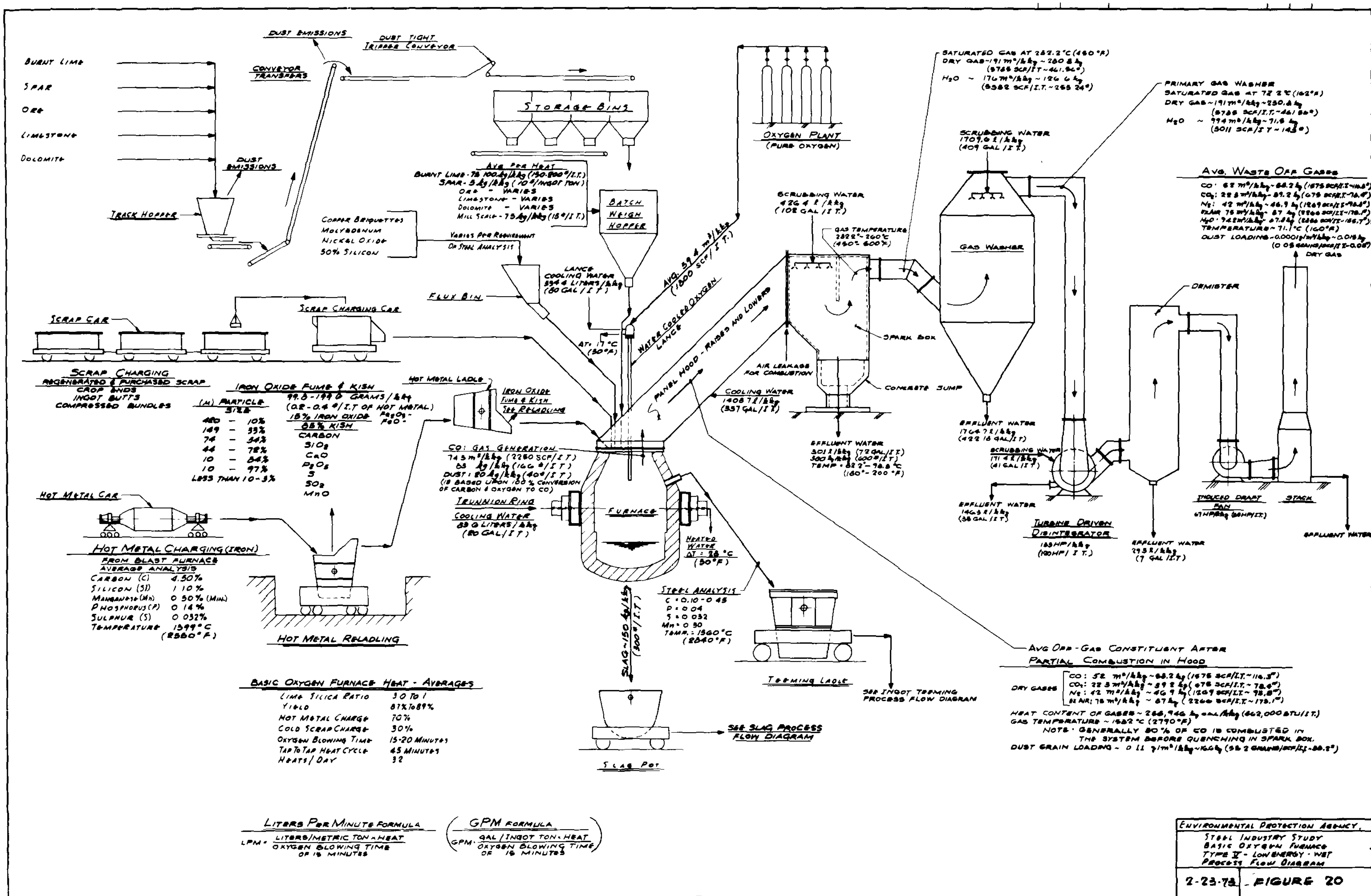


BURNT LIME
SPAR
ORE
LIMESTONE
DOLOMITE
TRACK HOPPER
DUST EMISSIONS
CONVEYOR TRANSFERS
DUST EMISSIONS
DUST TIGHT TRIPPER CONVEYOR
STORAGE BINS
BATCH WEIGH HOPPER
AVERAGE PER HEAT
BURNT LIME — 75 TO 100 kg/METRIC TON (150 TO 200 LB/INGOT TON)
SPAR — 5 kg/METRIC TON (10 LB/INGOT TON)
ORE — VARIES
LIMESTONE — VARIES
DOLOMITE — VARIES
MILL SCALE — 7.5 kg/METRIC TON (15 LB/INGOT TON)
OXYGEN PLANT
(PURE OXYGEN)
OXYGEN AVERAGE
59.4 m³/METRIC TON (1800 SCF/INGOT TON)
LANCE COOLING WATER
261 LITERS/METRIC TON (60 GAL/INGOT TON)
ΔT=17°C (30°F)
WATER COOLED OXYGEN LANCE
COPPER BRIQUETTES
MOLYBDENUM
NICKEL OXIDE
50% SILICON
VARIES PER REQUIREMENT OF STEEL ANALYSIS
FLUX BIN
CHUTE
SCRAP CAR
SCRAP CHARGING CAR
SCRAP CHARGING
REGENERATED & PURCHASED SCRAP
CROP ENDS
INGOT BUTTS
COMPRESSED BUNDLES
IRON OXIDE FUME & KISH
SEE RELADLING
HOT METAL LADLE
HEAT TRANSFER TO HOOD
26611-27,720 Kg cal/METRIC TON
(96,000-100,000 BTU/INGOT TON)
IRON OXIDE FUME & KISH FROM RELADLING
(μ) PARTICLE SIZE
420 — 10%
149 — 35%
74 — 54%
44 — 72%
10 — 84%
10 — 97%
LESS THAN 10 - 3%
99.8 TO 199 G GRAMS/METRIC TON
(0.2 TO 0.4 LB/INGOT TON OF HOT METAL)
15% IRON OXIDE Fe_2O_3 - FeO -
85% KISH
CARBON
SiO_2
CaO
P_2O_5
S
SO_2
MnO
HOT METAL CAR
HOT METAL CHARGING (IRON)
FROM BLAST FURNACE
AVERAGE ANALYSIS
CARBON (C) — 4.50%
SILICON (Si) — 1.10%
MANGANESE (Mn) — 0.80% MINIMUM
PHOSPHORUS (P) — 0.14%
SULPHUR (S) — 0.032%
TEMPERATURE — 1399°C (2550°F)
HOT METAL RELADLING
TRUNNION RING COOLING WATER
83.8 LITERS/METRIC TON (20 GAL/INGOT TON)
BASIC OXYGEN FURNACE HEAT - AVERAGES
LIME SILICA RATIO — 3.0 TO 1.0
YIELD — 87 TO 89%
HOT METAL CHARGE — 70%
COLD SCRAP CHARGE — 30%
OXYGEN BLOWING TIME - 15 TO 20 MINUTES
TAP TO TAP HEAT CYCLE - 45 MINUTES
HEATS PER DAY — 32
CO GAS GENERATION
74.8 m³/METRIC TON (2260 SCF/INGOT TON)
86 kg/METRIC TON (166 LB/INGOT TON)
DUST: 10-12.5 kg/kkg (20-25 LBS/IT)
(IS BASED UPON 100% CONVERSION OF CARBON AND OXYGEN TO CO)
FURNACE
HEATED WATER
ΔT-28°C (50°F)
SLAG - 50 kg/MT (500#/IT)
SLAG POT
SEE SLAG PROCESS FLOW DIAGRAM
TEEMING LADLE
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
HOOD & SKIRT COOLING WATER
4764.2 l/kkg
(1140 GAL/IT)
BY-PASS STACK
SPRAY QUENCH WATER
COOLING WATER
ΔT=8.3°C (15°F)
QUENCHER
SATURATED GAS TEMP
77°C (170°F)
PRESSURE
EFFLUENT WATER FROM DEMISTER
EFFLUENT WATER
1337 l/kkg (320 GAL/IT)
10 kg/kkg (20 LBS/IT)
HIGH ENERGY VENTURI SCRUBBER
(67 PSIA/IT)
(45 WC-IT)
NITROGEN PURGE OFF
9.9 m³/METRIC TON
(300 SCF/INGOT TON)
PURGE NITROGEN TANK
(98% PURE NITROGEN)
SCRUBBER WATER
1379.4 l/kkg (330 GAL/IT)
DEMISTER
EFFLUENT WATER
PUMPED TO QUENCHER
1379.4 l/kkg (330 GAL/IT)
INDUCED DRAFT FAN
100 HP/kkg
(90 HP/IT)
-0.016 kg/cm²-kkg
(-57" WC-IT)
STACK
EFFLUENT
BURNER
GAS STORAGE HOLDER
64.8 cal/m³/kkg
(252 BTU/SCF/IT)
FUEL VALUE
ALTERNATE GAS STORAGE HOLDER
NATURAL GAS
1.65 m³/kkg (50 SCF/IT)
(AUTOMATIC IGNITION UPON CO GAS GENERATION IN FURNACE)
AVERAGE WASTE OFF GASES
(BEFORE COMBUSTION AT STACK)
TEMPERATURE - 76.67°C (168°F)
DUST LOADING - 0.0001 g/m³/kkg - 0.01 kg
(0.05 GRAINS/SCF/IT - 0.02#)
DRY GAS
AVG OFF-GAS CONSTITUENT AFTER PARTIAL COMBUSTION IN HOOD
DRY GASES
HEAT CONTENT OF GASES - 55,861 Kg cal/kkg (92,600 BTU/IT)
GAS TEMPERATURE - 1482.2°C (2700°F)
NOTE. SYSTEM DESIGN IS BASED ON AIR LEAKAGE RATE TO BURN 10% OF CO GAS GENERATED IN FURNACE
GAS TEMPERATURE IS BASED ON COOLING EFFECT OF WATER TUBE COOLED HOOD
DUST GRAIN LOADING
LITERS PER MINUTE FORMULA
LPM = LITERS/METRIC TON x HEAT / OXYGEN BLOWING TIME OF 15 MINUTES
GPM FORMULA
GPM = GAL/INGOT TON x HEAT / OXYGEN BLOWING TIME OF 15 MINUTES
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
TYPE II - OG WET
PROCESS FLOW DIAGRAM
2-26-73
FIGURE 17



Burnt Lime
Spar
Ore
Limestone
Dolomite
Track Hopper
Dust Emissions
Conveyor Transfers
Dust Emissions
Dust Tight Tripper Conveyor
Storage Bins
Batch Weigh Hopper
Average Per Heat
Burnt Lime - 78-100 kg/kkg (150-200#/I.T.)
Spar - 5 kg/kkg (10#/Ingot Ton)
Ore - Varies
Limestone - Varies
Dolomite - Varies
Mill Scale - 7.5 kg/kkg (15#/I.T.)
Copper Briquettes
Molybdenum
Nickel Oxide
50% Silicon
Varies per requirement of steel analysis
Flux Bin
Lance Cooling Water 83.1 Liters/Metric Ton (20 Gal/Ingot Ton)
ΔT = 17°C (30°F)
Water Cooled Oxygen Lance
Hood Cooling Water ΔT = 17°C (30°F)
Gas Cooling Spray Water 246 ℓ/kkg (59 Gal/I.T.)
Cooling water overflows small channel troughs & wets the steel plate walls continuously.
Avg 59.4 m³/kkg (1800 SCF/Ingot Ton)
Chamber Cooling Water 315.5 ℓ/kkg (75 Gal/I.T.)
Oxygen Plant (Pure Oxygen)
Spark Box (Alternate in place of wet evaporation chamber)
From Furnace
Spray Water 740 ℓ/kkg (177 Gal/I.T.)
To Dry Precipitators
Effluent Water 493.2 ℓ/kkg (118 Gal/I.T.)
Wet Evaporation Chamber
Unlined Steel Plate
Generally Approx 4180 ℓ/kkg Flow (1000 Gal/I.T.)
Gas Temp 260-288°C (500-550°F)
Dry Precipitators
Average Waste Off-Gases
Exhaust Stack
Induced Draft Fan w/ Gas Turbine or Electric Drive
Effluent Water
4-5 kg/kkg (8-10 LBS/I.T.)
313.5 ℓ/kkg (75 Gal/I.T.)
Precipitated Dry Dust
Scrap Car
Scrap Charging Car
Scrap Charging
Regenerated & Purchased Scrap
Crop Ends
Ingot Butts
Compressed Bundles
Open Hood Water Cooled Panel
Iron Oxide Fume & Kish
Iron Oxide Fume & Kish See Reladling
Hot Metal Ladle
Heat Transfer to Hood
27,720 - 41,580 kg Cal/kkg (100,000-150,000 BTU/I.T.)
Hood Cooling Water 2506 ℓ/kkg (600 Gal/I.T.)
Hot Metal Car
Hot Metal Charging (Iron) From Blast Furnace Average Analysis
Hot Metal Reladling
Trunnion Ring Cooling Water 83.6 Liters/kkg (20 Gal/Ingot Ton)
Furnace
CO: Gas Generation
Heated Water ΔT = 28°C (50°F)
Steel Analysis
C - 0.10-0.45
P - .004
S - .032
Mn - 0.30
Temp - 1960°C (2840°F)
Avg Off-Gas Constituent After Combustion in Hood
Slag - 150 kg/M.T. (300#/Ingot Ton)
Slag Pot
See Slag Process Flow Diagram
Teeming Ladle
See Ingot Teeming Process Flow Diagram
Basic Oxygen Furnace Heat - Averages
Lime Silica Ratio - 3.0 to 1
Yield - 87% - 89%
Hot Metal Charge - 70%
Cold Scrap Charge - 30%
Oxygen Blowing Time - 15-20 Minutes
Tap to Tap Heat Cycle - 45 Minutes
Heats/Day - 32
Liters Per Minute Formula
LPM = Liters/Metric Ton x Heat / Oxygen Blowing Time of 15 Minutes
GPM Formula
GPM = Gal/Ingot Ton x Heat / Oxygen Blowing Time of 15 Minutes
Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type III - Semi-Wet
Process Flow Diagram
2-15-73
FIGURE 18


Burnt Lime
Spar
Ore
Limestone
Dolomite
Track Hopper
Dust Emissions
Conveyor Transfers
Dust Tight Tripper Conveyor
Storage Bins
Batch Weigh Hopper
Average Per Heat
Burnt Lime — 75 To 100 kg/Metric Ton (150 To 200 Lb/Ingot Ton)
Spar — 5 kg/Metric Ton (10 Lb/Ingot Ton)
Ore — Varies
Limestone — Varies
Dolomite — Varies
Mill Scale — 7.5 kg/Metric Ton (15 Lb/Ingot Ton)
Copper Briquettes
Molybdenum
Nickel Oxide
50% Silicon
Varies Per Requirement Of Steel Analysis
Flux Bin
Lance Cooling Water 251 Liters/kkg (60 Gal/I.T.)
Water Cooled Oxygen Lance
Steam
Avg 594 m³/Metric Ton (1800 ft³/Ingot Ton)
Oxygen Plant (Pure Oxygen)
Steam Drum
By-Pass Stack
Steam Accumulator
Blowdown
Steam To Plant
Saturated Steam
Scrap Car
Scrap Charging Car
Scrap Charging
Reverberated & Purchased Scrap
Crop Ends
Ingot Butts
Compressed Bundles
Iron Oxide Fume & Kish From Reladling
Iron Oxide Fume & Kish See Reladling
Hot Metal Ladle
Hot Metal Car
Hot Metal Charging (Iron) From Blast Furnace
Average Analysis
Carbon (C) — 4.50%
Silicon (Si) — 1.10%
Manganese (Mn) — 0.90% Minimum
Phosphorus (P) — 0.14%
Sulphur (S) — 0.032%
Temperature — 1399°C (2550°F)
Hot Metal Reladling
Boiler Heat Transfer
Trunnion Ring Cooling Water
CO Gas Generation
Furnace
Heated Water ΔT = 28°C (50°F)
Steel Analysis
Slag Pot
See Slag Process Flow Diagram
Teeming Ladle
See Ingot Teeming Process Flow Diagram
Gas Flow
Quencher
Saturated Gas Temp. - 83.3°C (182°F)
Effluent Water From Separator
Waste Heat Boiler
Effluent Water
High Energy Venturi Scrubber
Water Supply
Separator
Spray Water
Alternate On Scrubbing System
Cooling Tower
Cooling Water
In order to reduce horsepower consumption of fans, tall packed steel cooling towers are installed with a recycle water cooling system. Additional water that is discharged from cooling tower is due to condensation of water vapor in saturated gases.
Tile Lining
Induced Draft Fan
Stack
Effluent Water
Effluent Water Pumped To Quencher
Avg. Saturated Waste Off Gases
Dry Gas
Avg Off-Gas Constituent After Combustion In Hood
Dry Gases
Note: Excess air determined final gas temperature. 50% excess air or less is the general design of the wet scrubber systems. Final gas temperatures are only approximate due to dissociation of CO_2 at these high gas temperatures.
Basic Oxygen Furnace Heat - Averages
Lime Silica Ratio — 3.0 To 1.0
Yield — 87 To 89%
Hot Metal Charge — 70%
Cold Scrap Charge — 30%
Oxygen Blowing Time — 15 To 20 Minutes
Tap To Tap Heat Cycle — 45 Minutes
Heats Per Day — 32
Liters Per Minute Formula
LPM = Liters/Metric Ton x Heat / Oxygen Blowing Time of 15 Minutes
GPM Formula
GPM = Gal/Ingot Ton x Heat / Oxygen Blowing Time of 15 Minutes
Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type IV - Wet
Process Flow Diagram
2-22-73
FIGURE 19



Burnt Lime
Spar
Ore
Limestone
Dolomite
Dust Emissions
Conveyor Transfers
Dust Tight Tripper Conveyor
Track Hopper
Storage Bins
Oxygen Plant
(Pure Oxygen)
Batch Weigh Hopper
Avg. Per Heat
Copper Briquettes
Molybdenum
Nickel Oxide
50% Silicon
Varies Per Requirement On Steel Analysis
Flux Bin
Lance Cooling Water
Water Cooled Oxygen Lance
Panel Hood - Raised and Lowered
Scrubbing Water
Gas Temperature
Spark Box
Air Leakage For Combustion
Concrete Sump
Cooling Water
Effluent Water
Gas Washer
Scrubbing Water
Saturated Gas
Primary Gas Washer
Demister
Avg. Waste Off Gases
Dry Gas
Turbine Driven Disintegrator
Induced Draft Fan
Stack
Effluent Water
Scrap Car
Scrap Charging Car
Scrap Charging
Regenerated & Purchased Scrap
Crop Ends
Ingot Butts
Compressed Bundles
Iron Oxide Fume & Kish
Particle Size
Hot Metal Ladle
Iron Oxide Fume & Kish See Reladling
CO: Gas Generation
Trunnion Ring Cooling Water
Furnace
Heated Water
Steel Analysis
Teeming Ladle
See Ingot Teeming Process Flow Diagram
Hot Metal Car
Hot Metal Charging (Iron)
From Blast Furnace Average Analysis
Carbon (C) 4.50%
Silicon (Si) 1.10%
Manganese (Mn) 0.50% (Min)
Phosphorus (P) 0.14%
Sulphur (S) 0.032%
Temperature 1399°C (2550°F)
Hot Metal Reladling
Slag Pot
See Slag Process Flow Diagram
Avg Off-Gas Constituent After Partial Combustion in Hood
Basic Oxygen Furnace Heat - Averages
Lime Silica Ratio 3.0 To 1
Yield 81% To 89%
Hot Metal Charge 70%
Cold Scrap Charge 30%
Oxygen Blowing Time 15-20 Minutes
Tap To Tap Heat Cycle 45 Minutes
Heats/Day 32
Liters Per Minute Formula
LPM = Liters/Metric Ton x Heat / Oxygen Blowing Time of 15 Minutes
GPM Formula
GPM = Gal/Ingot Ton x Heat / Oxygen Blowing Time of 15 Minutes
Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type V - Low Energy - Wet
Process Flow Diagram
2-23-73
Figure 20

A system of valves in the flues effect the gas reversal so that heat stored in checkers is used to preheat the incoming furnace combustion air. In some plants, the gases leaving the checkers pass through waste heat boilers which further reduce the waste gas temperature to 260-315°C. Sometimes pure oxygen is lanced over the bath to speed up the oxidation (refining) cycle. The tap to tap time will vary from five to 8 hours with oxygen lancing as oppose to eight to 12 hours without oxygen. Where the basin refactory material is composed of silica sand, the furnace is described as an "Acid" Furnace and when the basin is lined with dolomite or magnesite it is termed a "Basic" Furnace. The "Basic" Open Hearth process is the method generally used in the United States due to the Basic Process being able to remove phosphorus and sulfur from iron and ores whereas "Acid" Furnace requires selected raw materials that contain minimum amounts of these elements. Most ores mined in the United States contain some amounts of phosphorus and sulfur.

The open hearth cycle consists of several stages i.e., fettling, charging, meltdown, hot metal addition, ore and lime boil, refining, tapping, and delay. The period of time between tap and start (fettling) is spent on normal repairs to the hearth and plugging the tap hole used in the previous heat.

During the charging period, the solid raw materials such as pig iron, iron ore, limestone, scrap iron and steel are dumped into the furnace by special charging machines. The melting period begins when the first scrap has been charged. The direction of the flame is then reversed every 15-20 minutes. When the solid material has melted, a charge of hot metal is put into the furnace. This is normal procedure for a "hot-metal" furnace but in the case of a "cold metal" furnace, solid materials are added usually in two batch charges. The hot metal addition is followed by the ore and lime boil, caused by oxidized gases rising to surface of the melt.

Carbon monoxide is generated by oxidation of carbon and is called "ore boil". When the carbon dioxide is released in calcination of the limestone, the turbulence is called "lime boil". The refining period is used to lower the steel phosphorus and sulfur content to specified levels, eliminate carbon and allow time for proper conditioning of slag and attainment of proper bath temperature. At the end of the working period, the furnace is tapped at a bath temperature of approximately 1,650°C.

The waste products from the open hearth process are slag, oxides of iron ejected as submicron dust and waste gases composed of air, carbon dioxide, water vapor, oxides of sulfur and nitrogen (due to the nature of certain fuels being burned) and oxides of zinc if quantities of galvanized steel scrap are used. Fluorides may be emitted from open hearth furnaces both as gaseous and particulate matter. In most instances, the source of fluoride is fluorspar (CaF_2) used during the final stage of the heat. Iron oxide fume (dust) is generated at the rate of 12.5 kg/kkg (lb/1,000 lb) of steel. The gas and dust generation rate is fairly constant over the heat cycle except during oxygen lancing.

The older shops did not have any type of gas cleaning equipment and the fume and gases were ejected through the waste heat stacks.

Some of the newer shops are equipped with dust collection units and some of the older shops have added collection systems. Two types again are used, precipitators or venturi scrubbers. As the precipitators are generally dry systems, no waterborne effluents are discharged. The venturi scrubbers do discharge an effluent and because of the presence of sulphur oxides, the water is of acid nature.

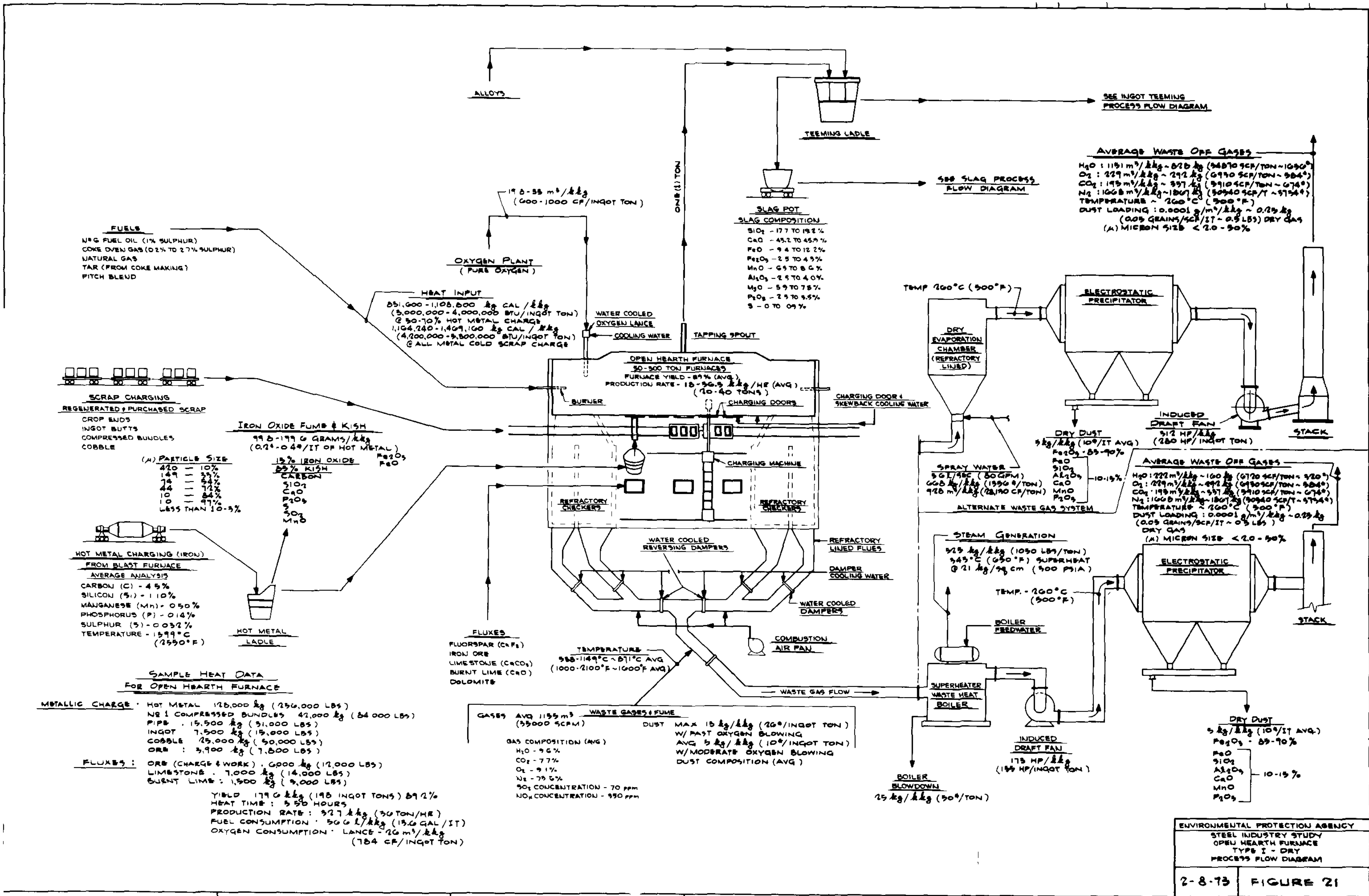
More specific details of the open hearth process are shown on Figures 21,22 and 23.

Electric Arc Furnace Operation

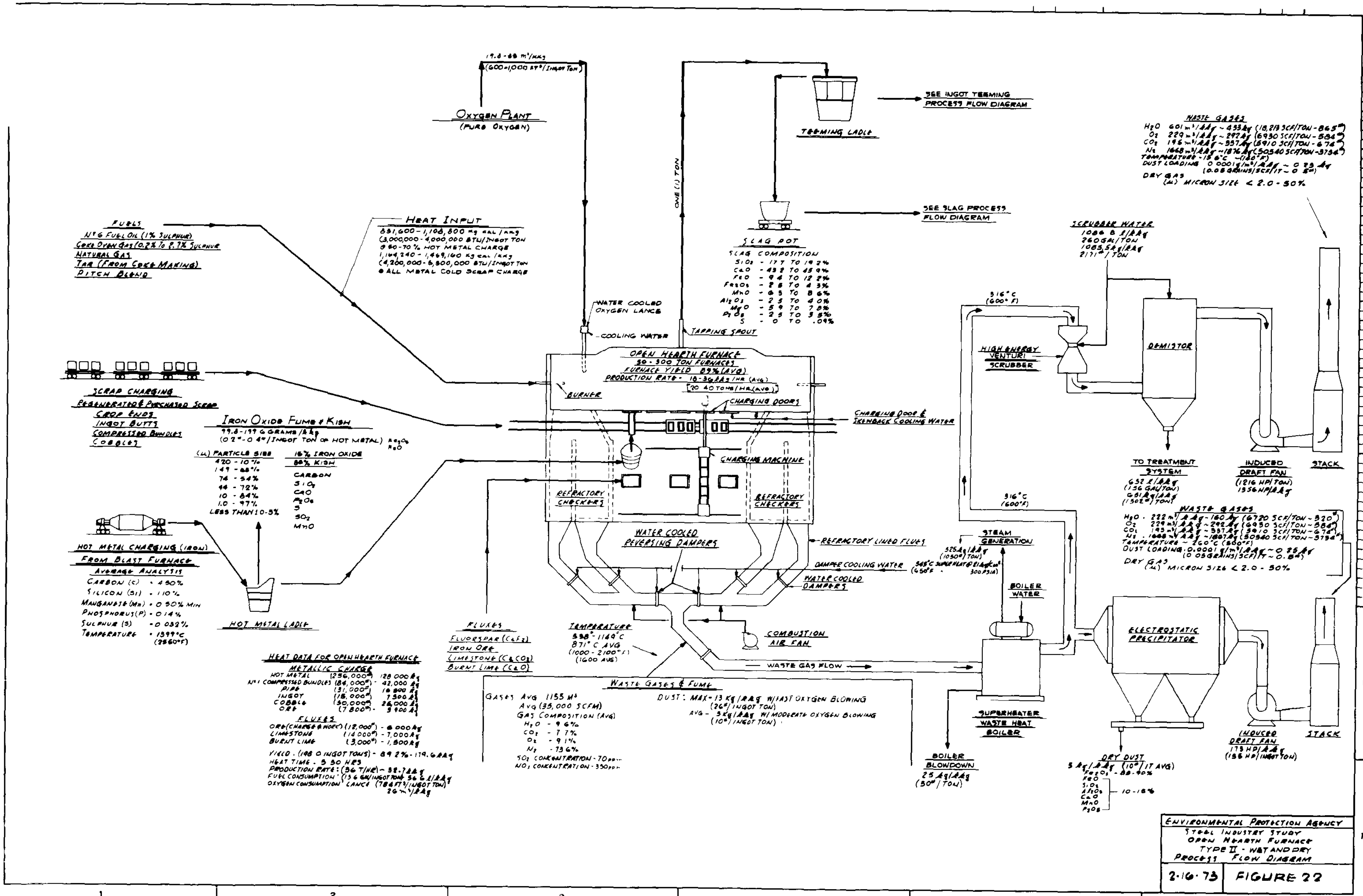
The electric arc furnace steelmaking process is a method of producing high quality and alloy steels in refractory lined cylindrical furnaces utilizing a cold steel scrap charge and fluxes. Sometimes a portion of hot metal will be charged or a lower grade of steel is produced in the basic oxygen furnace or open hearth and then is alloyed in the electric furnace. The latter is known as duplexing. The heat for melting the scrap charge, fluxes, etc., is furnished by passing an electric current (arcing) through the scrap or steel bath by means of three (3) triangularly spaced cylindrical carbon electrodes inserted through the furnace roof.

The electrodes are consumable and oxidize at a rate of five to eight kg/kkg (lb/1,000 lb) of steel. Larger tonnage furnaces have hinged removal roofs for scrap addition while smaller furnaces are charged through furnace doors. Furnaces range in size from 18 to 365 kkg (20 to 400 ton) heats and 2 to 9 m (approximately 2 to 10 yds) in diameter. The heat cycle time is generally four to five hours. Production of some high quality steels requires the use of two different slags for the same heat, referred to as oxidizing and reducing slags. The first slag is removed from the furnace and new fluxes added for the second slag. The period of a reducing slag requires a slight positive pressure be maintained in furnace to prevent infiltration of air or further oxidizing of steel. The heat cycle generally consists of charging, meltdown, molten metal period, oxidizing, refining and tapping (pouring). Pure oxygen is sometimes lanced across the bath to speed up the oxidation cycle which in turn will reduce the electrical current consumption.

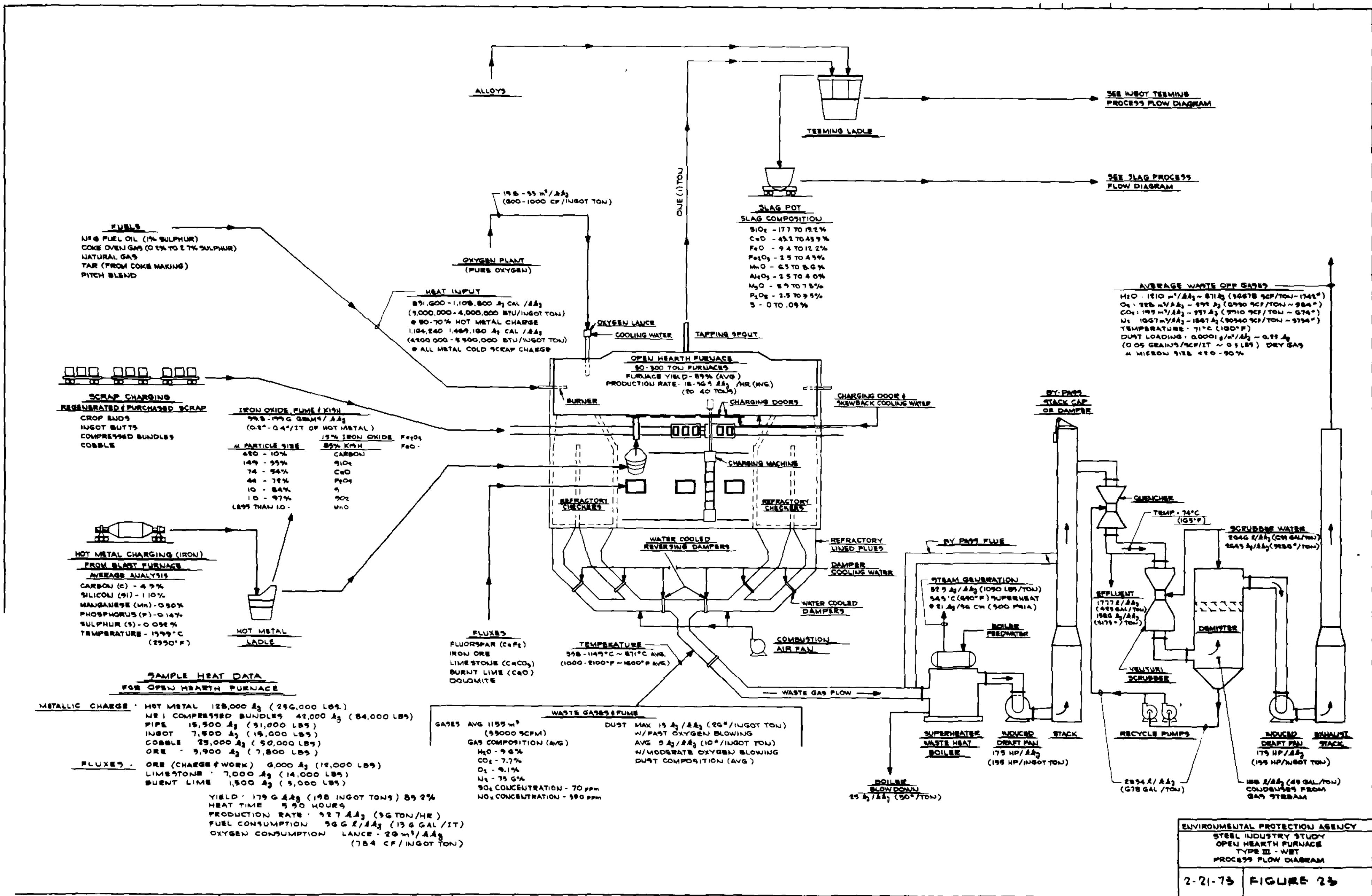
The waste products from the process are smoke, slag, carbon monoxide and dioxide gases and mainly oxides of iron emitted as submicron fume.



ALLOYS
TEEMING LADLE
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
ONE (1) TON
SLAG POT
SLAG COMPOSITION
SiO2 - 17.7 TO 19.2%
CaO - 43.2 TO 45.9%
FeO - 9.4 TO 12.2%
Fe2O3 - 2.5 TO 4.3%
MnO - 6.5 TO 8.6%
Al2O3 - 2.5 TO 4.0%
MgO - 5.9 TO 7.8%
P2O5 - 2.3 TO 3.5%
S - 0 TO 0.9%
SEE SLAG PROCESS FLOW DIAGRAM
AVERAGE WASTE OFF GASES
H2O : 1151 m³/kkg ~ 828 kg (34870 SCF/TON ~ 1650#)
O2 : 229 m³/kkg ~ 292 kg (6930 SCF/TON ~ 584#)
CO2 : 193 m³/kkg ~ 337 kg (5910 SCF/TON ~ 674#)
N2 : 1668 m³/kkg ~ 1807 kg (50940 SCF/T ~ 3754#)
TEMPERATURE ~ 260°C (500°F)
DUST LOADING : 0.0001 g/m³/kkg ~ 0.25 kg (0.05 GRAINS/SCF/IT ~ 0.5 LBS) DRY GAS
(μ) MICRON SIZE < 2.0 - 90%
FUELS
N° 6 FUEL OIL (1% SULPHUR)
COKE OVEN GAS (0.2% TO 2.7% SULPHUR)
NATURAL GAS
TAR (FROM COKE MAKING)
PITCH BLEND
19.8 - 33 m³/kkg
(600 - 1000 CF/INGOT TON)
OXYGEN PLANT
(PURE OXYGEN)
HEAT INPUT
851,600 - 1,108,800 kg CAL/kkg
(3,000,000 - 4,000,000 BTU/INGOT TON)
@ 30-70% HOT METAL CHARGE
1,164,240 - 1,469,100 kg CAL/kkg
(4,200,000 - 5,300,000 BTU/INGOT TON)
@ ALL METAL COLD SCRAP CHARGE
WATER COOLED OXYGEN LANCE
COOLING WATER
TAPPING SPOUT
OPEN HEARTH FURNACE
50-500 TON FURNACES
FURNACE YIELD - 89% (AVG)
PRODUCTION RATE - 18 - 36.3 kkg/HR (AVG)
(20-40 TONS)
BURNER
CHARGING DOORS
CHARGING DOOR & SKEWBACK COOLING WATER
CHARGING MACHINE
REFRACTORY CHECKERS
REFRACTORY CHECKERS
WATER COOLED REVERSING DAMPERS
REFRACTORY LINED FLUES
DAMPER COOLING WATER
WATER COOLED DAMPERS
COMBUSTION AIR FAN
SCRAP CHARGING
REGENERATED & PURCHASED SCRAP
CROP ENDS
INGOT BUTTS
COMPRESSED BUNDLES
COBBLE
IRON OXIDE FUME & KISH
99.8 - 199.6 GRAMS/kkg
(0.2# - 0.4#/IT OF HOT METAL)
Fe2O3
FeO
(μ) PARTICLE SIZE
420 — 10%
149 — 33%
74 — 54%
44 — 72%
10 — 84%
1.0 — 97%
LESS THAN 1.0 - 3%
15% IRON OXIDE
85% KISH
CARBON
SiO2
CaO
P2O5
S
SO2
MnO
HOT METAL CHARGING (IRON)
FROM BLAST FURNACE
AVERAGE ANALYSIS
CARBON (C) - 4.5%
SILICON (Si) - 1.10%
MANGANESE (Mn) - 0.50%
PHOSPHORUS (P) - 0.14%
SULPHUR (S) - 0.032%
TEMPERATURE - 1399°C (2550°F)
HOT METAL LADLE
FLUXES
FLUORSPAR (CaF2)
IRON ORE
LIMESTONE (CaCO3)
BURNT LIME (CaO)
DOLOMITE
TEMPERATURE
538 - 1149°C ~ 871°C AVG
(1000 - 2100°F ~ 1600°F AVG)
WASTE GAS FLOW
GASES AVG 1155 m³ (35000 SCFM)
WASTE GASES & FUME
DUST MAX 15 kg/kkg (26#/INGOT TON)
W/ FAST OXYGEN BLOWING
AVG 5 kg/kkg (10#/INGOT TON)
W/ MODERATE OXYGEN BLOWING
DUST COMPOSITION (AVG)
GAS COMPOSITION (AVG)
H2O - 9.6%
CO2 - 7.7%
O2 - 9.1%
N2 - 73.6%
SO2 CONCENTRATION - 70 ppm
NOx CONCENTRATION - 550 ppm
SAMPLE HEAT DATA
FOR OPEN HEARTH FURNACE
METALLIC CHARGE : HOT METAL 126,000 kg (256,000 LBS)
Nº 1 COMPRESSED BUNDLES 42,000 kg (84 000 LBS)
PIPE : 15,500 kg (31,000 LBS)
INGOT 7,500 kg (15,000 LBS)
COBBLE 25,000 kg (50,000 LBS)
ORE : 3,900 kg (7,800 LBS)
FLUXES : ORE (CHARGE & WORK) : 6000 kg (12,000 LBS)
LIMESTONE : 7,000 kg (14,000 LBS)
BURNT LIME : 1,500 kg (3,000 LBS)
YIELD 179.6 kkg (198 INGOT TONS) 89.2%
HEAT TIME : 5.50 HOURS
PRODUCTION RATE : 32.7 kkg (36 TON/HR)
FUEL CONSUMPTION : 56.6 l/kkg (13.6 GAL/IT)
OXYGEN CONSUMPTION : LANCE - 26 m³/kkg
(784 CF/INGOT TON)
TEMP 260°C (500°F)
DRY EVAPORATION CHAMBER (REFRACTORY LINED)
ELECTROSTATIC PRECIPITATOR
INDUCED DRAFT FAN
312 HP/kkg
(280 HP/INGOT TON)
STACK
DRY DUST
5 kg/kkg (10#/IT AVG)
Fe2O3 - 85-90%
FeO
SiO2
Al2O3
CaO
MnO
P2O5
10-15%
SPRAY WATER
3.6 L/SEC (80 GPM)
668 kg/kkg (1336#/TON)
928 m³/kkg (28,150 CF/TON)
ALTERNATE WASTE GAS SYSTEM
AVERAGE WASTE OFF GASES
H2O : 222 m³/kkg ~ 160 kg (6720 SCF/TON ~ 320#)
O2 : 229 m³/kkg ~ 292 kg (6930 SCF/TON ~ 584#)
CO2 : 193 m³/kkg ~ 337 kg (5910 SCF/TON ~ 674#)
N2 : 1668 m³/kkg ~ 1807 kg (50940 SCF/T ~ 3754#)
TEMPERATURE ~ 260°C (500°F)
DUST LOADING : 0.0001 g/m³/kkg ~ 0.25 kg
(0.05 GRAINS/SCF/IT ~ 0.5 LBS)
DRY GAS
(μ) MICRON SIZE < 2.0 - 90%
STEAM GENERATION
525 kg/kkg (1050 LBS/TON)
343°C (650°F) SUPERHEAT
@ 21 kg/sq cm (300 PSIA)
TEMP. - 260°C (500°F)
BOILER FEEDWATER
SUPERHEATER WASTE HEAT BOILER
INDUCED DRAFT FAN
173 HP/kkg
(155 HP/INGOT TON)
BOILER BLOWDOWN
25 kg/kkg (50#/TON)
ELECTROSTATIC PRECIPITATOR
STACK
DRY DUST
5 kg/kkg (10#/IT AVG.)
Fe2O3 - 85-90%
FeO
SiO2
Al2O3
CaO
MnO
P2O5
10-15%
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
TYPE I - DRY
PROCESS FLOW DIAGRAM
2-8-73
FIGURE 21



OXYGEN PLANT
(PURE OXYGEN)
FUELS
No 6 FUEL OIL (1% SULPHUR)
COKE OVEN GAS (0.2% TO 0.7% SULPHUR
NATURAL GAS
TAR (FROM COKE MAKING)
PITCH BLEND
HEAT INPUT
SCRAP CHARGING
REGENERATED & PURCHASED SCRAP
CROP ENDS
INGOT BUTTS
COMPRESSED BUNDLES
COBBLES
IRON OXIDE FUME & KISH
HOT METAL CHARGING (IRON)
FROM BLAST FURNACE
AVERAGE ANALYSIS
HOT METAL LADLE
HEAT DATA FOR OPEN HEARTH FURNACE
METALLIC CHARGE
FLUXES
WATER COOLED OXYGEN LANCE
COOLING WATER
ONE (1) TON
TAPPING SPOUT
OPEN HEARTH FURNACE
50 - 300 TON FURNACES
BURNER
CHARGING DOORS
CHARGING DOOR & SKEWBACK COOLING WATER
CHARGING MACHINE
REFRACTORY CHECKERS
WATER COOLED REVERSING DAMPERS
REFRACTORY LINED FLUES
DAMPER COOLING WATER
WATER COOLED DAMPERS
COMBUSTION AIR FAN
TEMPERATURE
FLUXES
FLUORSPAR (CaF_2)
IRON ORE
LIMESTONE ($CaCO_3$)
BURNT LIME (CaO)
WASTE GASES & FUME
WASTE GAS FLOW
TEEMING LADLE
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
SLAG POT
SLAG COMPOSITION
SEE SLAG PROCESS FLOW DIAGRAM
SCRUBBER WATER
HIGH ENERGY VENTURI SCRUBBER
DEMISTOR
TO TREATMENT SYSTEM
INDUCED DRAFT FAN
STACK
WASTE GASES
STEAM GENERATION
BOILER WATER
SUPERHEATER WASTE HEAT BOILER
BOILER BLOWDOWN
ELECTROSTATIC PRECIPITATOR
DRY DUST
INDUCED DRAFT FAN
STACK
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
TYPE II - WET AND DRY
PROCESS FLOW DIAGRAM
2-16-73
FIGURE 22



ALLOYS
TEEMING LADLE
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
SEE SLAG PROCESS FLOW DIAGRAM
ONE (1) TON
SLAG POT
SLAG COMPOSITION
SiO_2 - 17.7 TO 19.2%
CaO - 43.2 TO 45.9%
FeO - 9.4 TO 12.2%
Fe_2O_3 - 2.5 TO 4.3%
MnO - 6.5 TO 8.6%
Al_2O_3 - 2.5 TO 4.0%
MgO - 5.9 TO 7.5%
P_2O_5 - 2.5 TO 9.5%
S - 0 TO .09%
FUELS
Nº6 FUEL OIL (1% SULPHUR)
COKE OVEN GAS (0.2% TO 2.7% SULPHUR)
NATURAL GAS
TAR (FROM COKE MAKING)
PITCH BLEND
19.8 - 33 m^3/kkg (600 - 1000 CF/INGOT TON)
OXYGEN PLANT (PURE OXYGEN)
HEAT INPUT
831,600 - 1,108,800 kg CAL/kkg
(3,000,000 - 4,000,000 BTU/INGOT TON)
@ 50-70% HOT METAL CHARGE
1,164,240 - 1,469,160 kg CAL/kkg
(4200,000 - 5,300,000 BTU/INGOT TON)
@ ALL METAL COLD SCRAP CHARGE
OXYGEN LANCE
COOLING WATER
TAPPING SPOUT
OPEN HEARTH FURNACE
50 - 300 TON FURNACES
FURNACE YIELD - 89% (AVG)
PRODUCTION RATE - 18 - 36.3 kkg/HR (AVG) (20 - 40 TON/HR)
BURNER
CHARGING DOORS
CHARGING DOOR & SKEWBACK COOLING WATER
CHARGING MACHINE
REFRACTORY CHECKERS
REFRACTORY CHECKERS
SCRAP CHARGING
REGENERATED & PURCHASED SCRAP
CROP ENDS
INGOT BUTTS
COMPRESSED BUNDLES
COBBLE
IRON OXIDE FUME / KISH
95.8 - 199G GRAMS/kkg (0.2# - 0.4#/IT OF HOT METAL)
µ PARTICLE SIZE
420 - 10%
149 - 35%
74 - 54%
44 - 72%
10 - 84%
10 - 97%
LESS THAN 10 -
15% IRON OXIDE Fe_2O_3 FeO
85% KISH
CARBON
SiO_2
CaO
P_2O_5
S
SO_2
MnO
HOT METAL CHARGING (IRON)
FROM BLAST FURNACE
AVERAGE ANALYSIS
CARBON (C) - 4.5%
SILICON (Si) - 1.10%
MANGANESE (Mn) - 0.50%
PHOSPHORUS (P) - 0.14%
SULPHUR (S) - 0.032%
TEMPERATURE - 1399°C (2550°F)
HOT METAL LADLE
FLUXES
FLUORSPAR (CaF_2)
IRON ORE
LIMESTONE ($CaCO_3$)
BURNT LIME (CaO)
DOLOMITE
WATER COOLED REVERSING DAMPERS
REFRACTORY LINED FLUES
DAMPER COOLING WATER
WATER COOLED DAMPERS
COMBUSTION AIR FAN
TEMPERATURE
538 - 1149°C ~ 871°C AVG.
(1000 - 2100°F ~ 1600°F AVG.)
WASTE GAS FLOW
WASTE GASES & FUME
GASES AVG 1155 m^3 (35000 SCFM)
GAS COMPOSITION (AVG)
H_2O - 9.6%
CO_2 - 7.7%
O_2 - 9.1%
N_2 - 73.6%
SO_2 CONCENTRATION - 70 ppm
NO_x CONCENTRATION - 390 ppm
DUST MAX 13 kg/kkg (26#/INGOT TON) W/FAST OXYGEN BLOWING
AVG 5 kg/kkg (10#/INGOT TON) W/MODERATE OXYGEN BLOWING
DUST COMPOSITION (AVG)
SAMPLE HEAT DATA
FOR OPEN HEARTH FURNACE
METALLIC CHARGE · HOT METAL 128,000 kg (256,000 LBS.)
Nº1 COMPRESSED BUNDLES 42,000 kg (84,000 LBS)
PIPE 15,500 kg (31,000 LBS)
INGOT 7,500 kg (15,000 LBS)
COBBLE 25,000 kg (50,000 LBS)
ORE · 3,900 kg (7,800 LBS)
FLUXES · ORE (CHARGE & WORK) 6,000 kg (12,000 LBS)
LIMESTONE · 7,000 kg (14,000 LBS)
BURNT LIME 1,500 kg (3,000 LBS)
YIELD · 179.6 kkg (198 INGOT TONS) 89.2%
HEAT TIME 5.50 HOURS
PRODUCTION RATE · 32.7 kkg (36 TON/HR)
FUEL CONSUMPTION 56.6 ℓ/kkg (13.6 GAL/IT)
OXYGEN CONSUMPTION LANCE - 29 m^3/kkg (784 CF/INGOT TON)
BY PASS FLUE
STEAM GENERATION
82.5 kg/kkg (1090 LBS/TON)
343°C (650°F) SUPERHEAT
8.81 kg/sq cm (500 PSIA)
BOILER FEEDWATER
SUPERHEATER WASTE HEAT BOILER
INDUCED DRAFT FAN
175 HP/kkg (155 HP/INGOT TON)
STACK
BOILER BLOWDOWN
25 kg/kkg (50#/TON)
BY-PASS STACK CAP OR DAMPER
QUENCHER
TEMP - 74°C (165°F)
EFFLUENT
VENTURI SCRUBBER
DEMISTER
SCRUBBER WATER
RECYCLE PUMPS
2834 ℓ/kkg (678 GAL/TON)
188 ℓ/kkg (49 GAL/TON) CONDENSED FROM GAS STREAM
INDUCED DRAFT FAN
175 HP/kkg (155 HP/INGOT TON)
EXHAUST STACK
AVERAGE WASTE OFF GASES
H_2O · 1210 m^3/kkg ~ 871 kg (38678 SCF/TON ~ 1742#)
O_2 · 228 m^3/kkg ~ 292 kg (6990 SCF/TON ~ 584#)
CO_2 · 195 m^3/kkg ~ 337 kg (5910 SCF/TON ~ 674#)
N_2 1067 m^3/kkg ~ 1867 kg (30940 SCF/TON ~ 3734#)
TEMPERATURE · 71°C (160°F)
DUST LOADING · 0.0001 g/m^3/kkg ~ 0.25 kg
(0.05 GRAINS/SCF/IT ~ 0.5 LBS) DRY GAS
µ MICRON SIZE < 10 - 50%
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
TYPE III - WET
PROCESS FLOW DIAGRAM
2-21-73
FIGURE 23

Other waste contaminants such as zinc oxides from galvanized scrap will be released dependent upon type and quality of scrap utilized. High oil bearing scrap will yield heavy reddish-black smoke as the oils are burned off at start of meltdown cycle. Oxides of nitrogen and ozone are released during the arcing of electrodes. Generally, 5 kg of dust/kkg (lb/1,000 lb) of steel is expected, but this may reach as high as 15 kg/kkg if inferior scrap is used. The waste products are airborne and do not become waterborne unless some type of wet fume collector is used. Three types of dust collectors are used--baghouses, scrubbers and dry precipitators. In addition to the type of dust collectors, there are generally four different means of exhausting the fume generated by the electric furnaces:

1. Plant rooftop or furnace building extraction
2. Local fume hoods
3. Water cooled roof elbow
4. Fourth hole extraction

The plant roof top or building extraction requires the sealing up of the shop buildings and installation of exhaust hoods in rooftop trusses for exhausting the fume as generated by furnaces. A baghouse collector is used for cleaning of the exhaust gases. This system requires huge volumes of exhaust air [36,500 cubic meters (1,300,000 cu ft) per minute for a shop consisting of five 45 kkg (50 ton) furnaces] and large baghouse collectors, but the system is readily adaptable to electric furnaces using the double slagging practice and does capture most fugitive emissions from other furnace operations such as tapping, slagging, etc.

The second type of furnace exhaust are local exhaust hoods fitted adjacent to door openings, electrode openings and around junctures between roof and furnace shell. A baghouse collector is used with this type of exhaust as fume, smoke, and gases are captured as they bleed through the furnace openings and enough cool air is drawn into system that the hot gases are tempered. These systems are not effective when hinged type furnace roofs are in an open position during scrap charging.

The third type and fourth type of furnace exhaust are similar except the water cooled elbows are generally tightly fitted to the furnace roofs and the hot gases are exhausted from furnace interior through the cooled elbow. A combustion air space is left between the water cooled elbow and the gas cleaning ductwork to provide for combustion air for any carbon monoxide gases being emitted from furnaces.

The fourth hole constitutes a fourth refractory lined hole in the furnace roof. A space is left between the fourth hole exhaust port and the gas cleaning ductwork to again provide combustion air for carbon monoxide gases being emitted from furnace. Both exhaust systems can be used with all three types of dust collectors. If baghouses are used, a spray chamber is added to gas cleaning system to condition the gas temperature to 135°C.

If precipitators are used, a spark box is added to the system to condition gases generally to 260°C but if high energy venturi scrubbers are used, the gases are quenched to their saturation temperature by means of quenchers located near the furnaces. The spray chamber, spark box and quenchers discharge a water effluent.

When the steel from any of the three steelmaking processes is tapped (poured) into the steel holding ladles (teeming ladles), the ladle of steel is transported by crane or ladle transfer car to a teeming or continuous casting area. Sometimes the customer's specifications require further treatment and alloying of the steel for which the steel is then first transported to a vacuum degassing process area.

More specific details of the electric furnace process are shown on Figures 24,25 and 26.

Vacuum Degassing Subcategory

In the vacuum degassing process, steel is further refined by subjecting the molten steel to a high vacuum (low pressure). This process further reduces hydrogen, carbon, and oxygen content, improves steel cleanliness, allows production of very low carbon steel and enhances mechanical properties of the steel. Vacuum degassing facilities fall into three major categories:

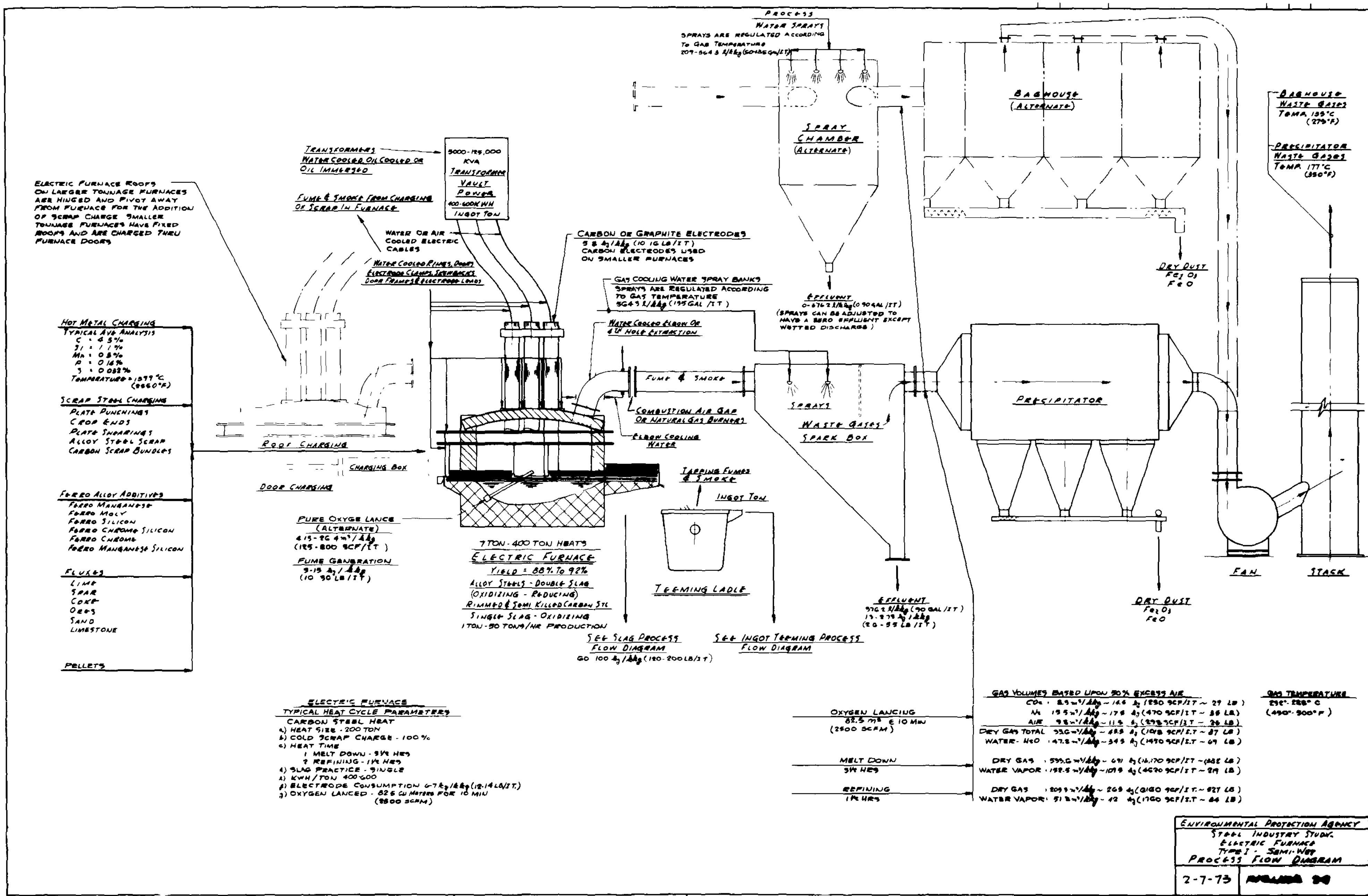
1. Recirculating degassing, where metal is forced into a refactory-lined degassing chamber by atmospheric pressure, exposed to low pressure (vacuum) and then discharged from chamber.

2. Stream degassing in which falling streams of molten metal are exposed to a vacuum and then collected under vacuum in an ingot mold or ladle.

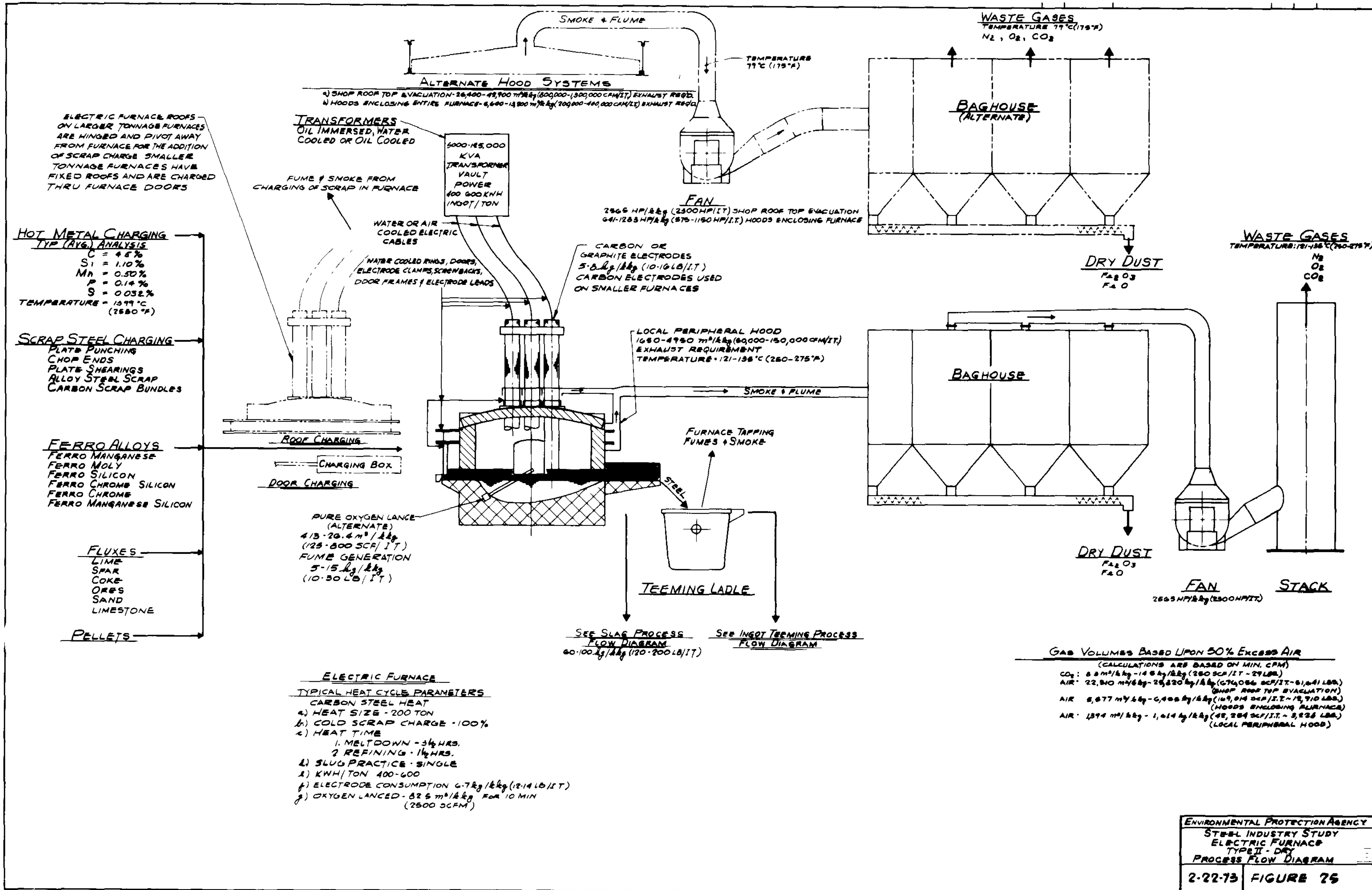
3. Ladle degassing, where the teeming ladle is subsequently positioned inside a degassing chamber where the metal is exposed to vacuum and stirred by argon gas or electrical induction.

The recirculatory systems are of two types D-H (Dortmund Horder) and the R-H (Ruhrstal-Heraeus).

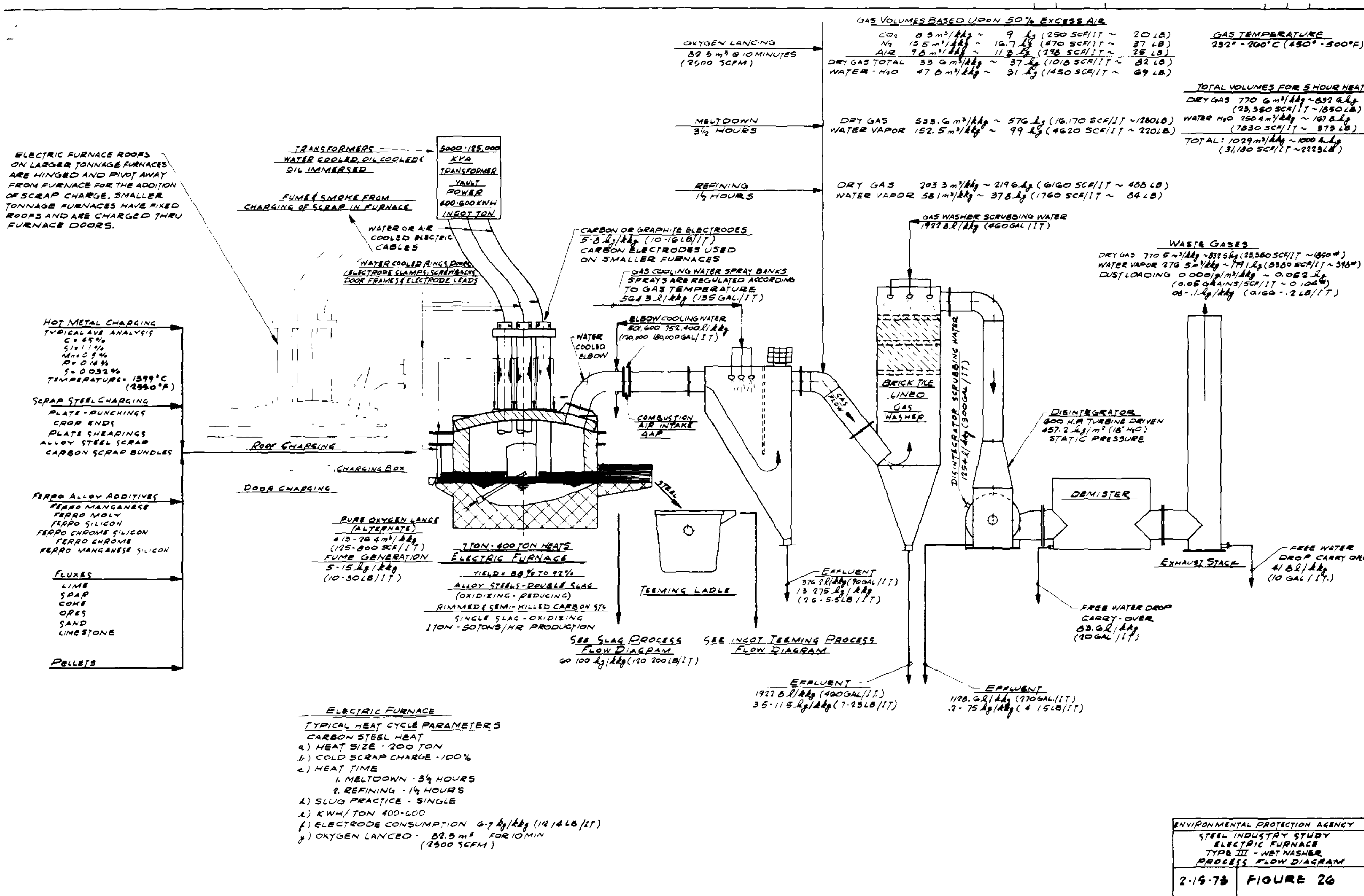
The R-H system is characterized by a continuous flow of steel through the degassing vessel by means of two nozzles inserted in the teeming ladle molten steel while the D-H system is characterized by a single nozzle inserted in the molten steel. The R-H system degassing chamber



PROCESS WATER SPRAYS
SPRAYS ARE REGULATED ACCORDING TO GAS TEMPERATURE
SPRAY CHAMBER (ALTERNATE)
BAGHOUSE (ALTERNATE)
BAGHOUSE WASTE GASES TEMP. 135°C (275°F)
PRECIPITATOR WASTE GASES TEMP. 177°C (350°F)
ELECTRIC FURNACE ROOFS ON LARGER TONNAGE FURNACES ARE HINGED AND PIVOT AWAY FROM FURNACE FOR THE ADDITION OF SCRAP CHARGE. SMALLER TONNAGE FURNACES HAVE FIXED ROOFS AND ARE CHARGED THRU FURNACE DOORS
TRANSFORMERS WATER COOLED, OIL COOLED OR OIL IMMERSED
5000-125,000 KVA TRANSFORMER VAULT POWER 400-600 KWH INGOT TON
FUME & SMOKE FROM CHARGING OF SCRAP IN FURNACE
WATER OR AIR COOLED ELECTRIC CABLES
WATER COOLED RINGS, DOORS, ELECTRODE CLAMPS, SKEWBACKS, DOOR FRAMES & ELECTRODE LEADS
CARBON OR GRAPHITE ELECTRODES
CARBON ELECTRODES USED ON SMALLER FURNACES
GAS COOLING WATER SPRAY BANKS
SPRAYS ARE REGULATED ACCORDING TO GAS TEMPERATURE
EFFLUENT
(SPRAYS CAN BE ADJUSTED TO HAVE A ZERO EFFLUENT EXCEPT WETTED DISCHARGE)
DRY DUST Fe_2O_3 FeO
WATER COOLED ELBOW OR 4TH HOLE EXTRACTION
FUME & SMOKE
COMBUSTION AIR GAP OR NATURAL GAS BURNERS
ELBOW COOLING WATER
SPRAYS
WASTE GASES
SPARK BOX
PRECIPITATOR
FAN
STACK
HOT METAL CHARGING
TYPICAL AVG ANALYSIS
C : 4.5%
Si : 1.1%
Mn : 0.8%
P : 0.16%
S : 0.032%
TEMPERATURE : 1399°C (2550°F)
SCRAP STEEL CHARGING
PLATE PUNCHINGS
CROP ENDS
PLATE SHEARINGS
ALLOY STEEL SCRAP
CARBON SCRAP BUNDLES
ROOF CHARGING
CHARGING BOX
DOOR CHARGING
FERRO ALLOY ADDITIVES
FERRO MANGANESE
FERRO MOLY
FERRO SILICON
FERRO CHROME SILICON
FERRO CHROME
FERRO MANGANESE SILICON
FLUXES
LIME
SPAR
COKE
ORES
SAND
LIMESTONE
PELLETS
PURE OXYGEN LANCE (ALTERNATE)
(125-800 SCF/I.T.)
FUME GENERATION
7 TON - 400 TON HEATS
ELECTRIC FURNACE
YIELD = 88% TO 92%
ALLOY STEELS - DOUBLE SLAG
(OXIDIZING - REDUCING)
RIMMED & SEMI KILLED CARBON STL
SINGLE SLAG - OXIDIZING
1 TON - 50 TONS/HR PRODUCTION
TAPPING FUMES & SMOKE
INGOT TON
TEEMING LADLE
SEE SLAG PROCESS FLOW DIAGRAM
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
ELECTRIC FURNACE
TYPICAL HEAT CYCLE PARAMETERS
CARBON STEEL HEAT
a) HEAT SIZE - 200 TON
b) COLD SCRAP CHARGE - 100%
c) HEAT TIME
1 MELT DOWN - 3½ HRS
2 REFINING - 1½ HRS
d) SLAG PRACTICE - SINGLE
e) KWH/TON 400-600
f) ELECTRODE CONSUMPTION
g) OXYGEN LANCED - 82.5 CU METERS FOR 10 MIN (2500 SCFM)
OXYGEN LANCING
(2500 SCFM)
MELT DOWN
3½ HRS
REFINING
1½ HRS
GAS VOLUMES BASED UPON 50% EXCESS AIR
CO₂
N₂
AIR
DRY GAS TOTAL
WATER - H₂O
DRY GAS
WATER VAPOR
DRY GAS
WATER VAPOR
GAS TEMPERATURE
(450°-500°F)
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
TYPE I - SEMI-WET
PROCESS FLOW DIAGRAM
2-7-73



SMOKE & FLUME
TEMPERATURE 79°C (175°F)
ALTERNATE HOOD SYSTEMS
a) SHOP ROOF TOP EVACUATION - 26,400-42,900 m³/kkg (800,000-1,300,000 CFM/IT) EXHAUST REQD.
b) HOODS ENCLOSING ENTIRE FURNACE - 6,600-13,200 m³/kkg (200,000-400,000 CFM/IT) EXHAUST REQD.
WASTE GASES
TEMPERATURE 79°C (175°F)
N2, O2, CO2
BAGHOUSE
(ALTERNATE)
ELECTRIC FURNACE ROOFS ON LARGER TONNAGE FURNACES ARE HINGED AND PIVOT AWAY FROM FURNACE FOR THE ADDITION OF SCRAP CHARGE. SMALLER TONNAGE FURNACES HAVE FIXED ROOFS AND ARE CHARGED THRU FURNACE DOORS
TRANSFORMERS
OIL IMMERSED, WATER COOLED OR OIL COOLED
5000-125,000 KVA TRANSFORMER VAULT
POWER 400 600 KWH INGOT / TON
FUME & SMOKE FROM CHARGING OF SCRAP IN FURNACE
FAN
2565 HP/kkg (2300 HP/IT) SHOP ROOF TOP EVACUATION
641-1283 HP/kkg (575-1150 HP/I.T.) HOODS ENCLOSING FURNACE
DRY DUST
Fe2O3
FeO
WATER OR AIR COOLED ELECTRIC CABLES
WATER COOLED RINGS, DOORS, ELECTRODE CLAMPS, SCREWBACKS, DOOR FRAMES & ELECTRODE LEADS
CARBON OR GRAPHITE ELECTRODES
5-8 kg/kkg (10-16 LB/I.T)
CARBON ELECTRODES USED ON SMALLER FURNACES
HOT METAL CHARGING
TYP (AVG) ANALYSIS
C = 4.5%
Si = 1.10%
Mn = 0.50%
P = 0.14%
S = 0.032%
TEMPERATURE = 1399°C (2550°F)
SCRAP STEEL CHARGING
PLATE PUNCHING
CHOP ENDS
PLATE SHEARINGS
ALLOY STEEL SCRAP
CARBON SCRAP BUNDLES
FERRO ALLOYS
FERRO MANGANESE
FERRO MOLY
FERRO SILICON
FERRO CHROME SILICON
FERRO CHROME
FERRO MANGANESE SILICON
FLUXES
LIME
SPAR
COKE
ORES
SAND
LIMESTONE
PELLETS
ROOF CHARGING
CHARGING BOX
DOOR CHARGING
LOCAL PERIPHERAL HOOD
1660-4950 m³/kkg (60,000-150,000 CFM/IT)
EXHAUST REQUIREMENT
TEMPERATURE - 121-136°C (250-275°F)
SMOKE & FLUME
WASTE GASES
N2
O2
CO2
BAGHOUSE
FURNACE TAPPING FUMES & SMOKE
STEEL
PURE OXYGEN LANCE (ALTERNATE)
4.3-26.4 m³/kkg (125-800 SCF/IT)
FUME GENERATION
5-15 kg/kkg (10-30 LB/IT)
TEEMING LADLE
SEE SLAG PROCESS FLOW DIAGRAM
60-100 kg/kkg (120-200 LB/IT)
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
DRY DUST
Fe2O3
FeO
FAN
2565 HP/kkg (2300 HP/IT)
STACK
ELECTRIC FURNACE
TYPICAL HEAT CYCLE PARAMETERS
CARBON STEEL HEAT
a) HEAT SIZE - 200 TON
b) COLD SCRAP CHARGE - 100%
c) HEAT TIME
1. MELTDOWN - 3¼ HRS.
2. REFINING - 1¼ HRS.
d) SLAG PRACTICE - SINGLE
e) KWH/TON 400-600
f) ELECTRODE CONSUMPTION 6-7 kg/kkg (12-14 LB/IT)
g) OXYGEN LANCED - 82.5 m³/kkg FOR 10 MIN (2500 SCFM)
GAS VOLUMES BASED UPON 50% EXCESS AIR
(CALCULATIONS ARE BASED ON MIN. CFM)
(SHOP ROOF TOP EVACUATION)
(HOODS ENCLOSING FURNACE)
(LOCAL PERIPHERAL HOOD)
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
TYPE II - DRY
PROCESS FLOW DIAGRAM
2-22-73
FIGURE 25



ELECTRIC FURNACE ROOFS ON LARGER TONNAGE FURNACES ARE HINGED AND PIVOT AWAY FROM FURNACE FOR THE ADDITION OF SCRAP CHARGE. SMALLER TONNAGE FURNACES HAVE FIXED ROOFS AND ARE CHARGED THRU FURNACE DOORS.
TRANSFORMERS WATER COOLED OIL COOLED & OIL IMMERSED
5000-125,000 KVA TRANSFORMER VAULT POWER 400-600 KWH INGOT TON
FUME & SMOKE FROM CHARGING OF SCRAP IN FURNACE
WATER OR AIR COOLED ELECTRIC CABLES
WATER COOLED RINGS, DOORS, ELECTRODE CLAMPS, SCREWBACKS, DOOR FRAMES & ELECTRODE LEADS
CARBON OR GRAPHITE ELECTRODES 5-8 kg/kkg (10-16 LB/IT) CARBON ELECTRODES USED ON SMALLER FURNACES
GAS COOLING WATER SPRAY BANKS SPRAYS ARE REGULATED ACCORDING TO GAS TEMPERATURE 564.3 l/kkg (135 GAL/IT)
ELBOW COOLING WATER 501,600 752,400 l/kkg (120,000 180,000 GAL/IT)
WATER COOLED ELBOW
COMBUSTION AIR INTAKE GAP
OXYGEN LANCING 82.5 m³ @ 10 MINUTES (2500 SCFM)
MELTDOWN 3½ HOURS
REFINING 1½ HOURS
GAS VOLUMES BASED UPON 50% EXCESS AIR
CO2 8.3 m³/kkg ~ 9 kg (250 SCF/IT ~ 20 LB)
N2 15.5 m³/kkg ~ 16.7 kg (470 SCF/IT ~ 37 LB)
AIR 9.8 m³/kkg ~ 11.3 kg (296 SCF/IT ~ 25 LB)
DRY GAS TOTAL 33.6 m³/kkg ~ 37 kg (1018 SCF/IT ~ 82 LB)
WATER - H2O 47.8 m³/kkg ~ 31 kg (1450 SCF/IT ~ 69 LB)
DRY GAS 533.6 m³/kkg ~ 576 kg (16,170 SCF/IT ~ 1280 LB)
WATER VAPOR 152.5 m³/kkg ~ 99 kg (4620 SCF/IT ~ 220 LB)
DRY GAS 203.3 m³/kkg ~ 219.6 kg (6160 SCF/IT ~ 488 LB)
WATER VAPOR 58 m³/kkg ~ 37.8 kg (1760 SCF/IT ~ 84 LB)
GAS TEMPERATURE 232° - 260°C (450° - 500°F)
TOTAL VOLUMES FOR 5 HOUR HEAT
DRY GAS 770.6 m³/kkg ~ 832 kg (23,350 SCF/IT ~ 1850 LB)
WATER H2O 258.4 m³/kkg ~ 167.8 kg (7830 SCF/IT ~ 373 LB)
TOTAL: 1029 m³/kkg ~ 1000 kg (31,180 SCF/IT ~ 2223 LB)
GAS WASHER SCRUBBING WATER 1922 8 l/kkg (460 GAL/IT)
WASTE GASES
DRY GAS 770.5 m³/kkg ~ 832.5 kg (23,350 SCF/IT ~ 1850#)
WATER VAPOR 276.5 m³/kkg ~ 179.1 kg (8380 SCF/IT ~ 398#)
DUST LOADING 0.0001 g/m³/kkg ~ 0.062 kg (0.06 GRAINS/SCF/IT ~ 0.104#)
.08 - .1 kg/kkg (.0166 - .2 LB/IT)
HOT METAL CHARGING
TYPICAL AVE ANALYSIS
C = 4.5%
Si = 1%
Mn = 0.5%
P = 0.14%
S = 0.032%
TEMPERATURE = 1399°C (2550°F)
SCRAP STEEL CHARGING
PLATE - PUNCHINGS
CROP ENDS
PLATE SHEARINGS
ALLOY STEEL SCRAP
CARBON SCRAP BUNDLES
ROOF CHARGING
CHARGING BOX
DOOR CHARGING
FERRO ALLOY ADDITIVES
FERRO MANGANESE
FERRO MOLY
FERRO SILICON
FERRO CHROME SILICON
FERRO CHROME
FERRO MANGANESE SILICON
FLUXES
LIME
SPAR
COKE
ORES
SAND
LIMESTONE
PELLETS
PURE OXYGEN LANCE (ALTERNATE) 4.13 - 26.4 m³/kkg (125-800 SCF/IT)
FUME GENERATION 5-15 kg/kkg (10-30 LB/IT)
1 TON - 400 TON HEATS ELECTRIC FURNACE
YIELD = 88% TO 92%
ALLOY STEELS - DOUBLE SLAG (OXIDIZING - REDUCING)
RIMMED & SEMI-KILLED CARBON STL SINGLE SLAG - OXIDIZING
1 TON - 50 TONS/HR PRODUCTION
STEEL
TEEMING LADLE
SEE SLAG PROCESS FLOW DIAGRAM 60-100 kg/kkg (120-200 LB/IT)
SEE INGOT TEEMING PROCESS FLOW DIAGRAM
EFFLUENT 376.2 l/kkg (90 GAL/IT) 13-2.75 kg/kkg (26-5.5 LB/IT)
GAS FLOW
BRICK TILE LINED GAS WASHER
DISINTEGRATOR SCRUBBING WATER 1254 l/kkg (300 GAL/IT)
DISINTEGRATOR 600 H.P. TURBINE DRIVEN 457.2 kg/m² (18" H2O) STATIC PRESSURE
DEMISTER
EXHAUST STACK
FREE WATER DROP CARRY OVER 41.8 l/kkg (10 GAL/IT)
FREE WATER DROP CARRY-OVER 83.6 l/kkg (20 GAL/IT)
EFFLUENT 1922.8 l/kkg (460 GAL/IT) 3.5 - 11.5 kg/kkg (7 - 23 LB/IT)
EFFLUENT 1128.6 l/kkg (270 GAL/IT) .2 - .75 kg/kkg (.4 - 1.5 LB/IT)
ELECTRIC FURNACE
TYPICAL HEAT CYCLE PARAMETERS
CARBON STEEL HEAT
a) HEAT SIZE - 200 TON
b) COLD SCRAP CHARGE - 100%
c) HEAT TIME
1. MELTDOWN - 3½ HOURS
2. REFINING - 1½ HOURS
d) SLAG PRACTICE - SINGLE
e) KWH/TON 400-600
f) ELECTRODE CONSUMPTION 6-7 kg/kkg (12-14 LB/IT)
g) OXYGEN LANCED - 82.5 m³ FOR 10 MIN (2500 SCFM)
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
TYPE III - WET WASHER
PROCESS FLOW DIAGRAM
2-15-73
FIGURE 26

and ladle are stationary while the D-H system ladle oscillates up and down.

A four or five stage steam jet ejector with barometric condenser is used to draw the vacuum. A means of providing heat is furnished in the process by electric carbon heating rods to replace heat loss in the process or in some cases to raise the temperature of the steel bath. Alloys are generally added during this process and cycle time is approximately 25 to 30 minutes.

The waste products from vacuum degassing process are condensed steam and waste with iron oxide fumes and CO gases entrained in the discharge effluent.

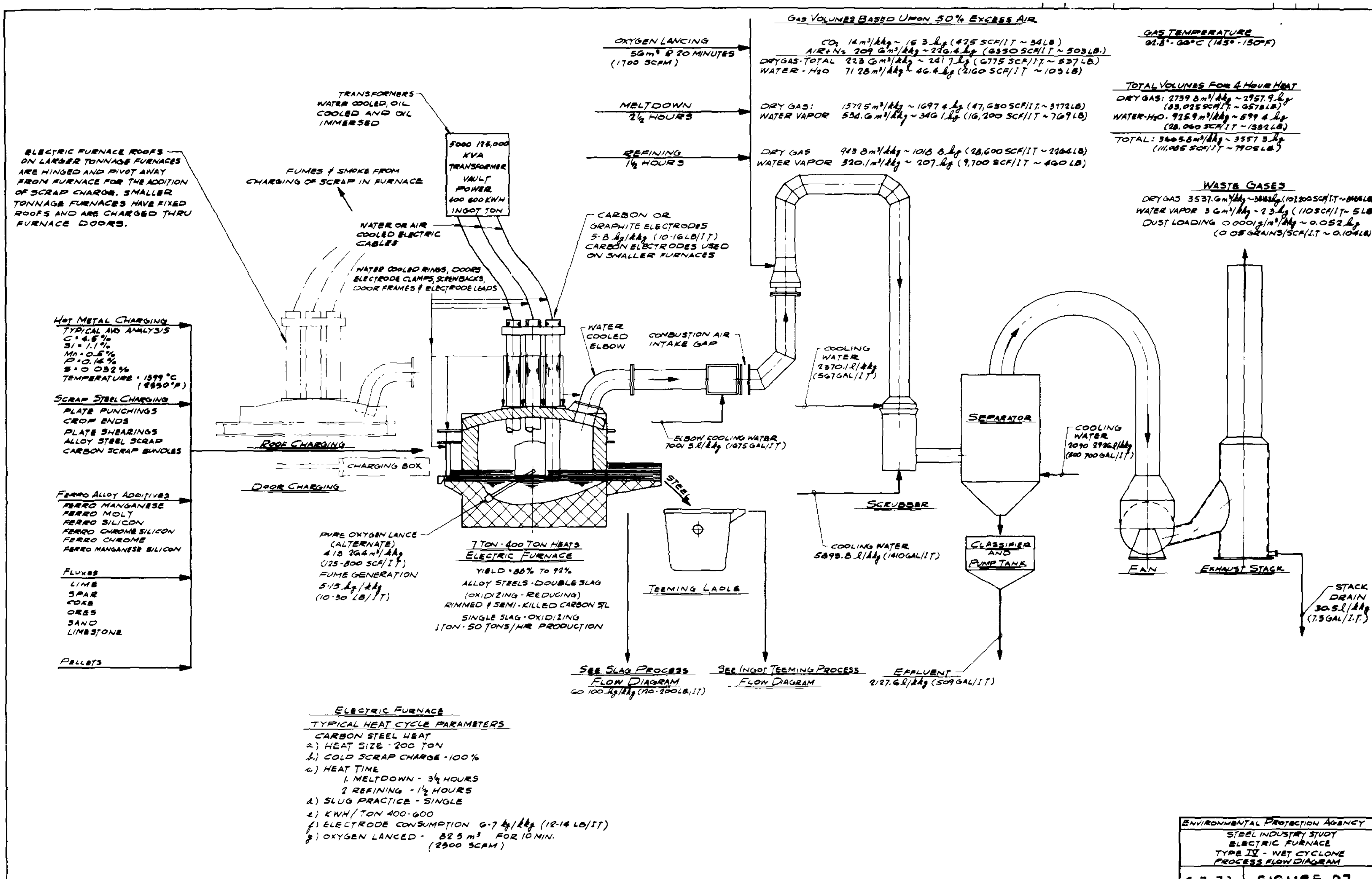
More specific details of the vacuum degassing process are shown on Figure 28.

Continuous Casting Subcategory

Steel that is not teemed into ingot molds can be cast in a process known as continuous casting. In the continuous casting process billets, blooms, slabs and other shapes are cast directly from the teeming ladle hot metal, thus eliminating the ingots, molds, mold preparation, soaking pits and stripping facilities. In this process, the steel ladle is suspended above a preheated covered steel refractory lined rectangular container with several nozzles in the bottom called a "tundish". The tundish regulates the flow of hot steel from teeming ladles to the continuous casting molds by means of nozzle orifice size, ferrostatic head or using stoppered nozzles to shut off the flow of steel.

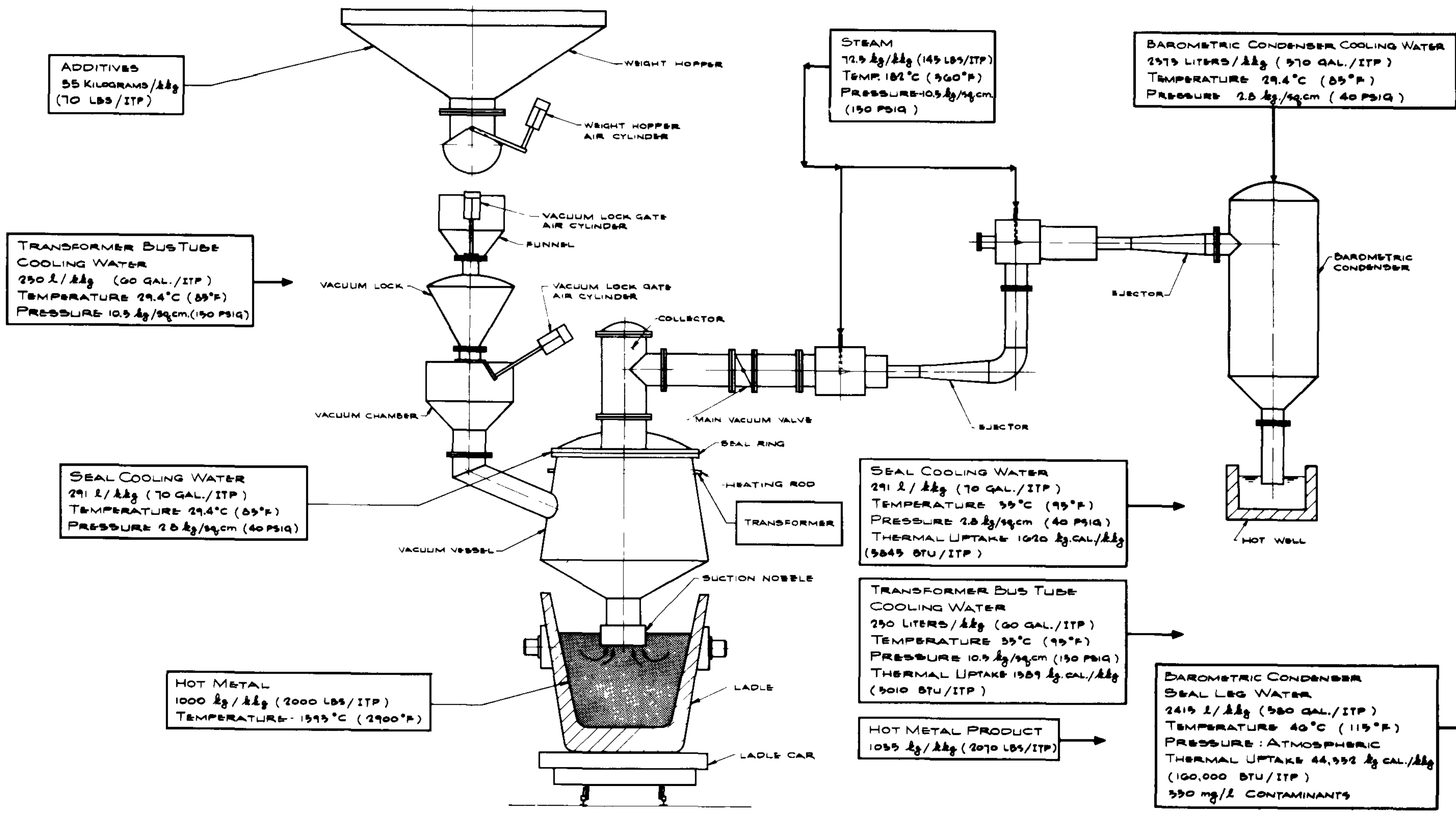
When casting billets or blooms, several parallel casting molds are served by one tundish. Each mold and its associated mechanical equipment is called a "strand" and casting units are generally two, four, or six strand machines.

The casting molds are water-cooled copper molds, chrome plated conforming to the desired shape to be cast. To start the casting process, a dummy bar is fed back into the strand and blocks the bottom of the mold opening. As the hot steel flows through the tundish nozzles into the casting mold, a hard steel exterior shape forms from the cooling with a molten steel center. The casting molds oscillate to prevent sticking and help discharge the solidified product from the mold. After the cast product is discharged from the molds, the cast product enters a spray chamber where sprays further cool the cast product. After the spray section, the cast product is either cut off by a shear or acetylene torch and product tipped to the horizontal for discharge through the "run-out" table and stacker units or the product is curved to the horizontal by means of bending rolls. After the product is in a horizontal direction, it is re-straightened and then cut to



Gas Volumes Based Upon 50% Excess Air
Oxygen Lancing 5Gm³ @ 20 Minutes (1700 SCFM)
Meltdown 2½ Hours
Refining 1½ Hours
Gas Temperature
Total Volumes For 4 Hour Heat
Waste Gases
Electric furnace roofs on larger tonnage furnaces are hinged and pivot away from furnace for the addition of scrap charge. Smaller tonnage furnaces have fixed roofs and are charged thru furnace doors.
Transformers water cooled, oil cooled and oil immersed
Fumes & smoke from charging of scrap in furnace
5000 126,000 KVA Transformer Vault Power 400 600 KWH Ingot Ton
Water or air cooled electric cables
Carbon or graphite electrodes
Carbon electrodes used on smaller furnaces
Water cooled rings, doors electrode clamps, screwbacks, door frames & electrode leads
Hot Metal Charging
Typical and Analysis
Scrap Steel Charging
Plate punchings
Crop ends
Plate shearings
Alloy steel scrap
Carbon scrap bundles
Roof Charging
Charging Box
Door Charging
Ferro Alloy Additives
Ferro manganese
Ferro moly
Ferro silicon
Ferro chrome silicon
Ferro chrome
Ferro manganese silicon
Fluxes
Lime
Spar
Coke
Ores
Sand
Limestone
Pellets
Pure oxygen lance (alternate)
Fume generation
Water cooled elbow
Combustion air intake gap
Elbow cooling water
Cooling water
Steel
Teeming Ladle
Scrubber
Separator
Classifier and Pump Tank
Fan
Exhaust Stack
Stack drain
Effluent
See Slag Process Flow Diagram
See Ingot Teeming Process Flow Diagram
7 Ton - 400 Ton Heats Electric Furnace
Yield - 88% to 92%
Alloy steels - double slag (oxidizing - reducing)
Rimmed & semi-killed carbon stl
Single slag - oxidizing
1 ton - 50 tons/hr production
Electric Furnace
Typical Heat Cycle Parameters
Carbon steel heat
a.) Heat size - 200 ton
b.) Cold scrap charge - 100%
c.) Heat time
1. Meltdown - 3½ hours
2 Refining - 1½ hours
d.) Slug practice - single
e.) KWH/Ton 400-600
f.) Electrode consumption 6-7 kg/kkg (12-14 LB/IT)
g.) Oxygen lanced - 82.5 m³ for 10 min. (2500 SCFM)
Environmental Protection Agency
Steel Industry Study
Electric Furnace
Type IV - Wet Cyclone
Process Flow Diagram
6-7-73

FIGURE 27



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSING
PROCESS FLOW DIAGRAM
2-14-73 FIGURE 28

desired length. The curved type of machine reduces the height requirements of the casting machine building.

Three water systems serve the casting machine; they include mold cooling, machine cooling and spraying. Mold and machine cooling are performed in closed recycle systems whereas the spray water is an open recycle system. The waste products from this process are iron oxide scale, oil contaminants from machinery, heat and a limited amount of gases from the acetylene torch cut off units. At the discharge zone of the spray chamber, "pinch rolls" regulate the speed of discharge of cast product from the molds. The casting strand contains other rolls called "apron" rolls and "support" rolls which keep the cast product in proper alignment.

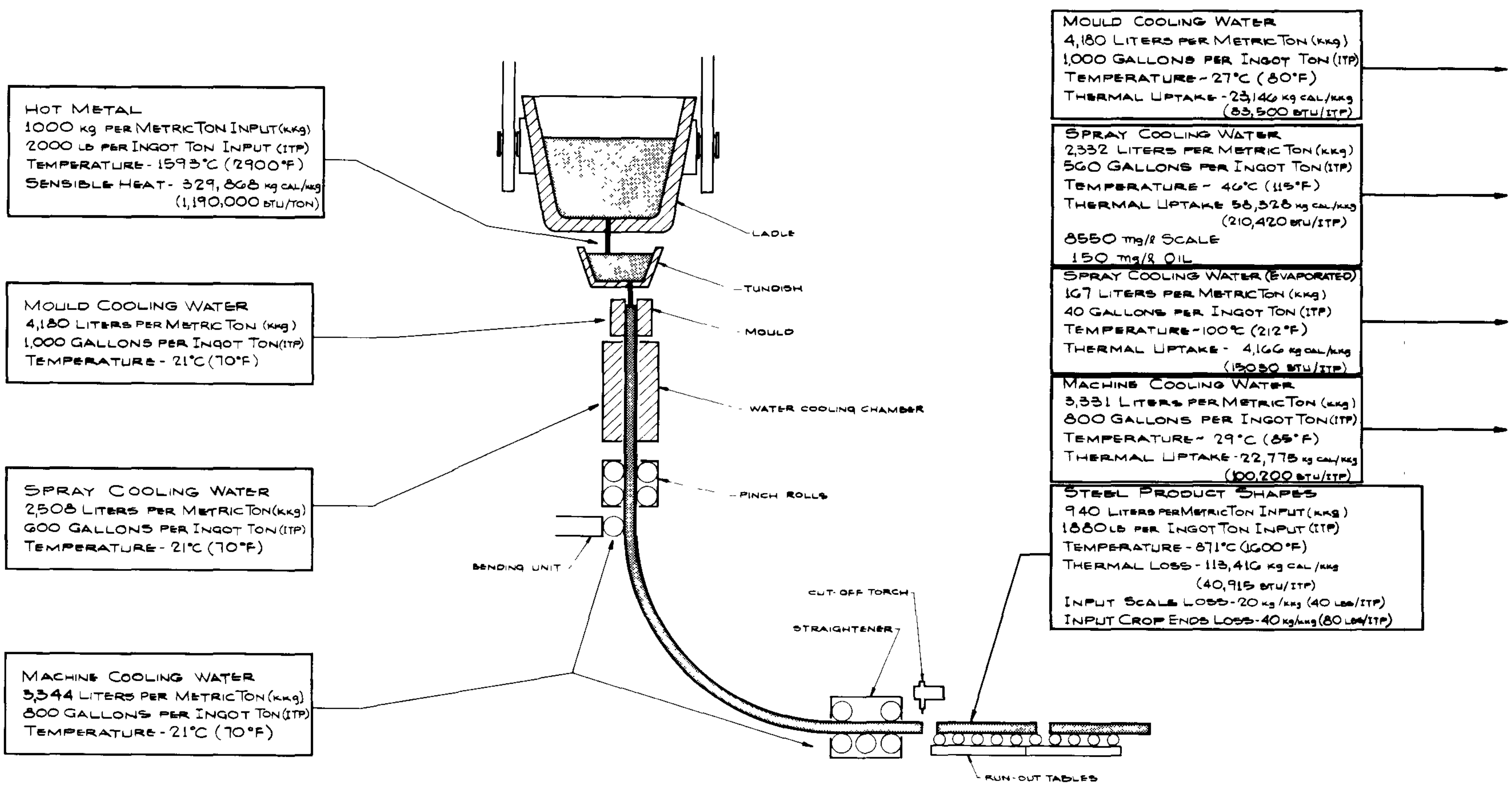
More specific details of the continuous casting operation are shown on Figure 29.

Ingot Casting Operation

The three steelmaking processes are housed in mill buildings and generally the building interior is identified by three main aisles called the charging aisle, furnace aisle, and the teeming aisle. The teeming aisle consists of a long building aisle with elevated brick lined platforms on one side where strings of flat bed railroad cars called "drags" are stationed. A drag generally will consist of five or six coupled cars.

On the bed of each car are stationed cast iron ingot molds and in turn the molds are seated on flat cast iron plates called "stools". The teeming aisle crane holds the ladle over each ingot mold. By means of a ladle stopper rod, operated by personnel stationed on teeming platforms, the steel is poured through a bottom ladle nozzle into the ingot mold. When the mold is filled, the operator closes the stopper rod which blocks the nozzle opening while the teeming crane shifts to next ingot mold. After finishing pouring the steel, the teeming crane dumps any slag remaining in the ladle and returns for another heat of steel.

The ingots are allowed to cool so a hard sheet forms and then drags are routed to a mold stripper area where the ingot mold is separated from the hot ingot by means of a special type stripper crane. The hot ingots are then transported to soaking pits where they are reheated in preparation for rolling in rolling mills. The ingot molds are transported to a mold preparation area, where they are cooled, cleaned and sprayed with an anti-sticking compound. During the teeming operation, some materials are added to the steel such as aluminum or lead shot. The aluminum acts as an oxidizing agent whereas lead is added for freer machining type steels. The waste products from teeming and mold cycle are contaminants that are airborne or have been spilled and reach sewers via groundwater.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
CONTINUOUS CASTING
PROCESS FLOW DIAGRAM

2-12-73 FIGURE 29

More specific details of the ingot casting operation are shown on Figure 30.

Pig Casting Operation

The molten iron from the blast furnace is generally used in the molten state in basic oxygen, open hearth, and electric furnaces. Occasionally due to equipment failures and production scheduling, it becomes necessary to cast the surplus molten iron into pigs. This is done in the pig machine.

Most pig machines consist of two strands of endless chains carrying a series of parallel cast-iron molds or troughs with overlapping edges which pass over a head and tail sprocket wheel. Molten iron is poured into the mold near the tail sprocket, solidifies and is cooled by water sprays as the chain rises to the head sprocket. As the chain reverses direction while passing over the head sprocket, the solid pig falls from the mold into waiting railroad cars or trucks. On the return travel of the chain, the molds are sprayed with a lime wash. This acts as a mold release and prevents the molten iron from adhering to the cast iron mold.

The lime wash used to coat the molds may create a housekeeping problem around the pig machine. Small volumes of water are used to wash down the area and to clean the spray equipment. Water is also required to cool the pigs. This water also washes off the surplus lime from the molds. Some plants may divert this runoff to a small basin which is periodically cleaned out. However, due to the small volume of water and the intermittent nature of the pig operation, there is no overflow from this pit.

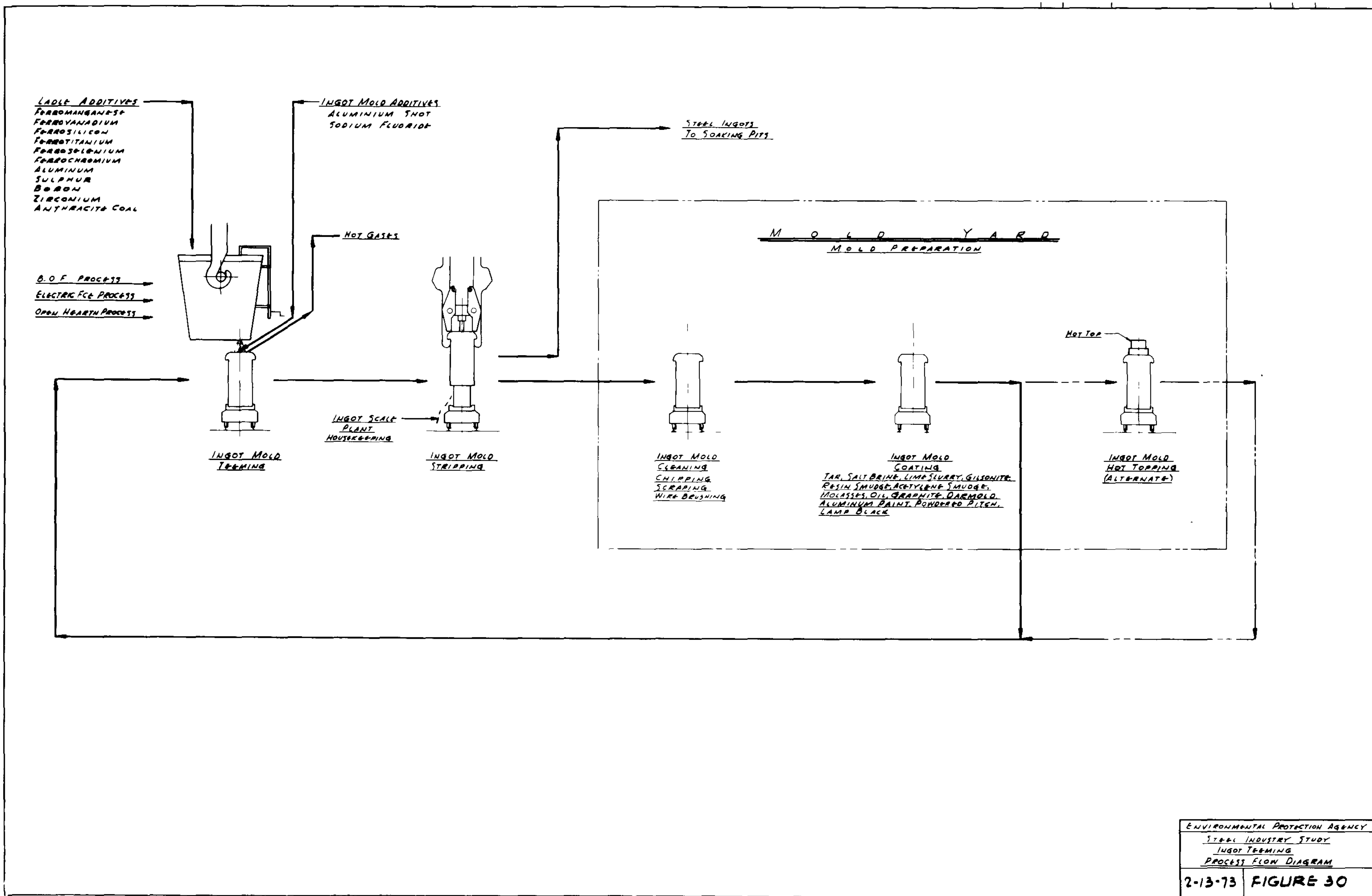
Generally, most plants limit the water use in the area and do not have a basin. Therefore, the water is controlled so as not to provide a poor working area.

Slagging Operation

For all of the three steelmaking processes, slag is always generated. The slag is generally deposited into ladles from the furnaces. These ladles are transported to a slag dump where the slag is allowed to air cool or is sprayed with water. The slag is then transported to a slag processing plant where the steel scrap is reclaimed and the slag crushed into a saleable product. The waste products from this process are generally airborne dust and become waterborne when wet dust collecting systems are added. When open hearth slag is wetted, hydrogen sulfide will be emitted due to sulfur content of slag.

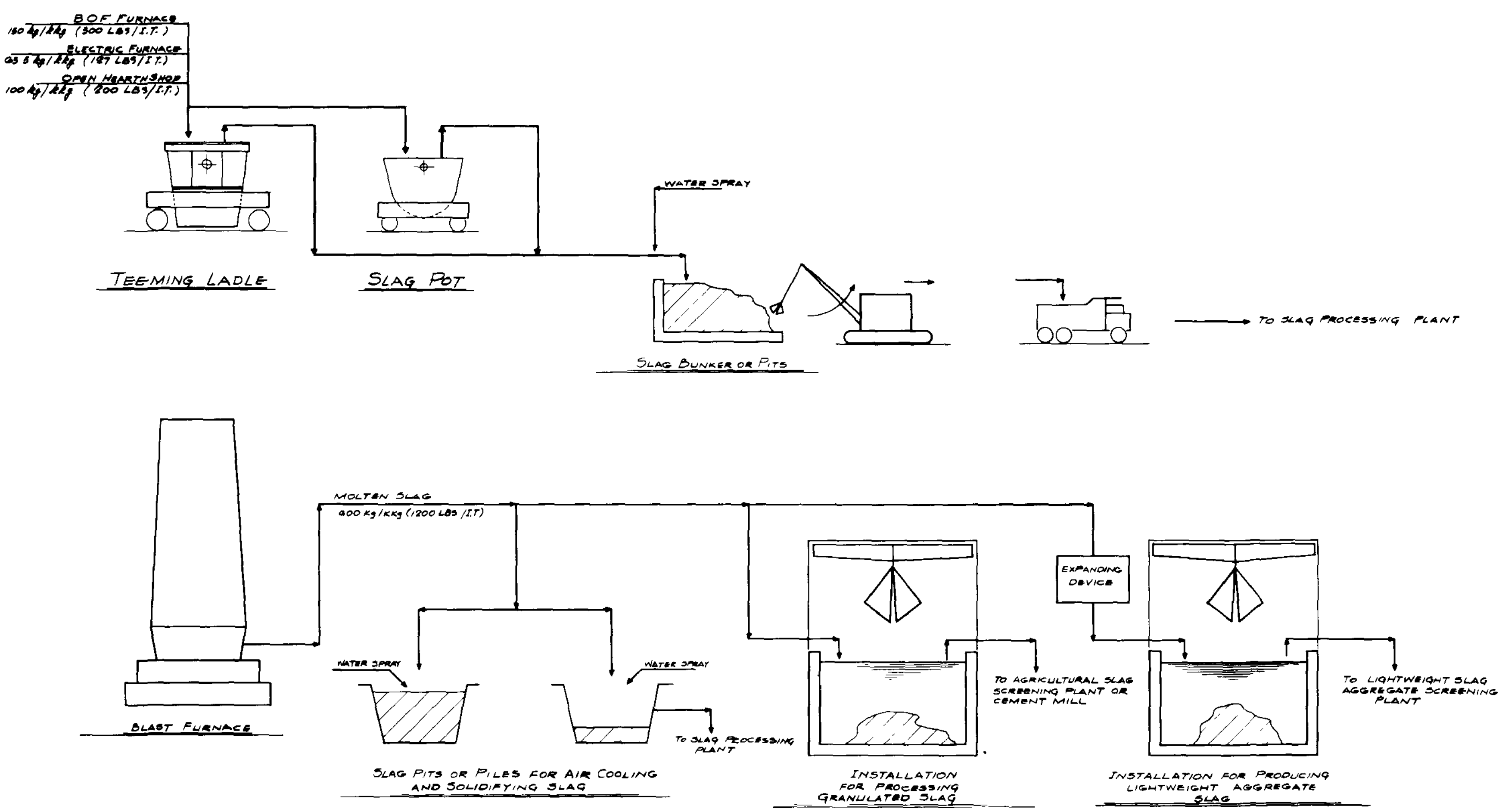
More specific details of the slagging operation are shown on Figure 31.

Rationale for Categorization - Factors Considered



LADLE ADDITIVES
FERROMANGANESE
FERROVANADIUM
FERROSILICON
FERROTITANIUM
FERROSELENIUM
FERROCHROMIUM
ALUMINUM
SULPHUR
BORON
ZIRCONIUM
ANTHRACITE COAL
INGOT MOLD ADDITIVES
ALUMINIUM SHOT
SODIUM FLUORIDE
HOT GASES
B.O.F. PROCESS
ELECTRIC FCE PROCESS
OPEN HEARTH PROCESS
STEEL INGOTS
TO SOAKING PITS
MOLD YARD
MOLD PREPARATION
HOT TOP
INGOT SCALE
PLANT
HOUSEKEEPING
INGOT MOLD
TEEMING
INGOT MOLD
STRIPPING
INGOT MOLD
CLEANING
CHIPPING
SCRAPING
WIRE BRUSHING
INGOT MOLD
COATING
TAR, SALT BRINE, LIME SLURRY, GILSONITE,
RESIN SMUDGE, ACETYLENE SMUDGE,
MOLASSES, OIL, GRAPHITE, DARMOLD,
ALUMINUM PAINT, POWDERED PITCH,
LAMP BLACK
INGOT MOLD
HOT TOPPING
(ALTERNATE)
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
INGOT TEEMING
PROCESS FLOW DIAGRAM
2-13-73

FIGURE 30



ENVIRONMENTAL PROTECTION AGENCY

STEEL INDUSTRY STUDY

SLAGGING

PROCESS FLOW DIAGRAM

2-21-73

FIGURE 31

With respect to identifying any relevant, discrete categories for the iron and steel industry, the following factors were considered in determining industry sub-categories for the purpose of the application of effluent limitation guidelines and standards of performance:

1. Manufacturing processes
2. Products
3. Waste water constituents
4. Gas cleaning equipment
5. Waste treatability
6. Size and age
7. Land availability
8. Aqueous waste loads
9. Process water usage

After considering all of these factors, was concluded that the iron and steel industry is comprised of separate and distinct processes with enough variability in product and waste to require categorizing into more than one giant unit operation. The individual processes, products, and the waste water constituents comprise the most significant factors in the categorization of this most complex industry. Process descriptions are provided in this section of the report delineating the detailed processes along with their products and sources of wastewaters. The use of various gas cleaning equipment, particularly in the steelmaking categories, lends itself to a further subdivision into wet, semi-wet, and dry subcategories. Gas cleaning is also discussed under process descriptions. Waste treatability in itself is of such magnitude that in some industries, categorization might be based strictly on the waste treatment process. However, with the categorization based primarily on the process with its products and wastes, it is more reasonable to treat each process waste treatment system under the individual category or subcategory. Waste treatability is discussed at length under Section VII, Control and Treatment Technology. Size and age of the plants has no direct bearing on the categorization. The processes and treatment systems are similar regardless of the age and size of the plant. Tables 34-43 provide, in addition to the plant size, the geographic location of the plant along with the age of the plant and the treatment plant. It can be noted that neither the wastes nor the treatment will vary in respect to the age or size factor. The aforementioned tables should be tied back to the discussion in Sections VII and VIII, related to raw waste loads, treatment systems and plant effluents. Therefore, age and size in itself would not substantiate industry categorization.

The number and type of pollutant parameters of significance varies with the operation being conducted and the raw materials used. The waste volumes and waste loads also vary with the operation. In order to prepare effluent limitation that would adequately reflect these variations in significant parameters and waste volumes the industry was

TABLE 34

Plant Age and Size
Coke Making - By-Product

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
A	Middle Atlantic	4610	1920	1960 & 1972
B	Middle Atlantic	4040	1925	1962 & 1964
C	Northern Great Lakes	5400	1940	1940 & 1958
D	Northeastern	1500	1918	1920 & 1951

TABLE 35

Plant Age and Size
Coke Making - Beehive

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
E	Middle Atlantic	907	1963	1963
F	Middle Atlantic	907	1970	1970
G	Northeastern	559	1960	1960

TABLE 36

Plant Age and Size
Burden Preparation - Sintering (II-A)

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
H	Middle Atlantic	5300		1940
I	Northern Great Lakes			
J	Northern Great Lakes	2300		1971
K	Northeastern			

TABLE 37

Plant Age and Size
Iron Making - Fe Blast Furnaces

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
L	Northern Great Lakes	2200	1941-1945	1971
M	Northern Great Lakes	3500 3500		
N	Central Pacific	1950	1941-1945	1959
O	Southern Texas	1500	1941-1945	1969
P	Northeastern	N/A	1900	----

TABLE 38

Plant Age and Size
Iron Making - FeMn Blast Furnaces

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
Q	Middle Atlantic	450	1941-1945	1968

TABLE 39

Plant Age and Size
Steel Making - Basic Oxygen Furnaces

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
R	Middle Atlantic	5300	1967	1967
S	Middle Atlantic	5760	1968	1968
T	Middle Atlantic	7217	1966	1966
U	Northern Great Lakes	2690	1959	1960 & 1964
V	Middle Atlantic	9880	1967	1967

TABLE 40

Plant Age and Size
Steel Making - Open Hearth Furnaces (IV-B)

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
W	Middle Atlantic	9150	1952	1968
X	Middle Atlantic	3330	1949-1955	1970

TABLE 41

Plant Age and Size
Steel Making - Electric Furnaces

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
Y	Middle Atlantic	1796	1955	1969
Z	Northern Great Lakes	1340	1967	1968
AA	Southern Texas	740	1967	1967
AB	Southern Texas	1451	1971	1971

TABLE 42

Plant Age and Size
Vacuum Degassing

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
AC	Middle Atlantic	6550 5950	1970	1970
AD	Southern Texas	1000	1971	1971

TABLE 43

Plant Age and Size
Continuous Casting

Plant	Location	Production kkg/day	Plant Installed Year	Treatment Plant Installed Year
AE	Middle Atlantic	2850	1969	1970
AF	Southern Texas	1450	1971	1971

subcategorized primarily along operational lines, with permatations where necessary, as indicated in Table 4.

TABLE 4

Subcategorization
of the
Steel Making Operations
of the
Iron and Steel Industry

I. By Product Coke Subcategory

II. Beehive Coke Subcategory

III. Sintering Subcategory

IV. Blast Furnace (Iron) Subcategory

V. Blast Furnace (Ferromanganese) Subcategory

VI. Basic Oxygen Furnace (Semi Wet Air Pollution
Control Methods) Subcategory

VII. Basic Oxygen Furnace (Wet Air Pollution
Control Methods) Subcategory

VIII. Open Hearth Furnace Operation

IX. Electric Arc Furnace (Semi Wet Air Pollution
Control Methods) Subcategory

X. Electric Arc Furnace (Wet Air Pollution
Control Methods) Subcategory

XI. Vacuum Degassing Subcategory

XII. Continuous Casting Subcategory

*Air Pollution Control Methods

Listings by the main subcategories have been compiled for all steel-making plants in the United States. They are presented in table form as follows:

TABLE	SUBCATEGORY
5.	By-Product Coke Plants
6.	Beehive Coke Plants
7.	Sintering
8.	Blast Furnace - Iron Making
9.	Blast Furnace - Ferromanganese
10.	Basic Oxygen Furnaces
11.	Open Hearth Furnaces
12.	Electric Arc Furnaces
13.	Vacuum Degassing
14.	Continuous Casting

The following sources were utilized to compile data on plants in each subcategory:

a. Directory of the Iron and Steel Works of the World, 5th Edition, Metal Bulletin Books Ltd., London, England.

b. AISI, Directory of the Iron and Steel Works of the U. S. and Canada, 1970.

c. Directory of Iron and Steel Plants, 1971

d. Battelle Coke Report

e. Iron and Steel Engineer, December, 1969; January, 1973.

f. EPA Project R800625 (unpublished)

g. 33 Magazine, July and October, 1972; July, 1970

h. Keystone Coal Industry Manual.

Selection of Candidate Plants for Visits

A survey of existing treatment facilities and their performance was undertaken to develop a list of best plants for consideration for plant visits. Information was obtained from:

(a) The study contractors personnel
(b) State Environmental Agencies
(c) EPA Personnel
(d) Personal Contact

(e) Literature Search

Since the steel industry is primarily situated in fifteen (15) states, greatest contribution was obtained from state and EPA personnel located in the following states:

a.	Alabama	b.	California	c.	Colorado
d.	Illinois	e.	Indiana	f.	Kentucky
g.	Maryland	h.	Michigan	i.	Missouri
j.	New York	k.	Ohio	l.	Pennsylvania
m.	Texas	n.	Utah	o.	West Virginia

Personal experiences and contacts provided information required to assess plant processes and treatment technology. Although an extensive literature search was conducted, the information was generally sketchy and could not be relied upon solely without further investigation.

Upon completion of this plant survey, the findings were compiled and preliminary candidate lists were prepared on those plants that were considered by more than one source to be providing the best waste treatment. These lists were submitted to the EPA by the study contractor for concurrence on sites to be visited. The rationale for plant selections in all the subcategories is presented in Table 15. In several instances, last minute substitutions had to be made because of the non-availability of the plant. In several other instances, while at the plant an additional sub-category was sampled to provide a complete study of several systems that were tied together, i.e., blast furnace-sinter plant, continuous casting-degassing-BOF. Table 16 presents a summary of the requirements for the study.

Tables five through fifteen are on file and available for perusal at the library of the Environmental Protection Agency, Washington, D.C. (Reference No. EP - 03B - 000 - 001).

TABLE 16

IRON AND STEELMAKING OPERATIONS
INDUSTRIAL CATEGORIZATION AND
SURVEY REQUIREMENTS

Main Category	Subcategory	Number of Locations Surveyed	Production Variations Within Subcategory to be Investigated	NO. SAMPLES EACH LOCATION Intake	Raw Waste	Treated Effluent	Cooling Water	Misc.
					Composite		Grab	
I. Coke Making								
	A. By-Product	4	Each of 4 types to preferably have different production unit operations	1	4	4	1	1
	B. Beehive	3	1 - Beehive type 1 - Rectangular slot type 1 - Once through wastewater	1	2	2	1	1
II. Burden Preparation								
	A. Sintering	3	3 - same type*	1	3	3	1	1
	B. Pelletizing	**	-					
	C. Briquetting	**	-					
III. Iron Making								
	A. Blast Furnace Iron	5	5 - same type*	1	3	3	2	1
	B. Blast Furnace Ferro Additives	1	1 - FeMn only due to nonavailability of other type ferro alloy furnaces	1	3	3	2	3
IV. Steelmaking								
	A. Basic Oxygen Furnace	5	2 - semi-wet type 3 - wet type	1	3	3	2	2
	B. Open Hearth	2	2 - same type*	1	3	3	1	1
	C. Electric Furnace	4	2 - semi-wet type 2 - wet type	1	3	3	1	1
V. Degassing	-	2	1 - DH type 1 - RH type	1	3	3	1	1
VI. Continuous Casting	-	2	1 - Billet Caster 1 - Slab Caster	1	3	3	1	1
VII. Fugitive Runoffs								
	A. Ingot Casting	1	-					1
	B. Pig Casting	1	-					1
	C. Coal Pile	1	-					1
	D. Ore Pile	1	-					1
	E. Stone Pile	1	-					1
	F. Slagging	3	1 - BF quench type 1 - BF spray cooled 1 - BOF spray cooled					1 1 1

*No major variations in production unit operations expected.

**No plants found operating as an integral part of an integrated steel mill.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

General

The waste water streams for the industry are described individually in their respective sub-categories. Waste loads were developed by actual plant sampling programs at selected exemplary plants on which EPA concurred. Raw waste loads are established as net plant raw waste loads. This is further defined as the contaminants attributable to the process of concern. It is the total or gross process load minus the contaminated load due to background (make-up). The basis for plant selection was primarily on their waste treatment practices. Therefore, further rationale for selection of the plant sites is presented under Section VII - Control and Treatment Technology.

Coke Making - By-Product Operation

General process and water flow schematics of a typical by-product coke plant and associated light oil recovery plant are presented on Figures 2 and 3.

Typical products from the carbonization of a metric ton of coal are as follows:

Gas	336 cu. m.	(12,000 cu ft)
Tar	38 l	(9.2 gal)
Ammonia	19 l	(4.6 gal)
Tar Acids	95 l	(23 gal)
Hydrogen Sulfide	21 l	(5 gal)
Light Oil	11 l	(2.6 gal)
Coke	636 kg	(1,400 lb)
Coke Breeze	95 kg	(210 lb)

Raw waste loads for by-product coke plants may vary due to the nature of the process, water use systems, moisture and volatility of the coal, and the carbonizing temperature of the ovens. Minimum and maximum values for plant effluents in the study ranged from 167-18,800 l/kkg (40 - 4,150 gal/ton) coke produced.

The most significant liquid wastes produced from the coke plant process are excess ammonia liquor, final cooling water overflow, light oil recovery wastes, and indirect cooling water. In addition, small volumes of water may result from coke wharf drainage, quench water overflow and coal pile runoff.

The volume of ammonia liquor produced varies from 100 to 170 l/kkg (24 to 41 gal/ton) of coke produced at plants using the semi-direct ammonia recovery process to 350 to 500 l/kkg (84 to 127 gal/ton) for the indirect process. This excess flushing liquor is the major single source of contaminated water from coke making.

Indirect (noncontact) cooling water is not normally considered waste but leaks in coils or tubes may contribute a significant source of pollution.

Direct contact of the gas in the final cooler with sprays of water dissolve any remaining soluble gas components and physically flush out crystals of condensed naphthalene, which is then recovered by skimming or filtration. This final cooler water becomes so highly contaminated that most plants must cool and recirculate this water. When a closed recycle system is not used, this waste water may exceed the raw ammmonia liquor as the source of high contaminant loads.

Condensed steam from the stripping operations and cooling water constitute the bulk of liquid wastes discharged to the sewer. Light oil recovery wastes will vary with the plant process. Flows may vary from 2,100 to 6,300 l/kkg (500 to 1,500 gal/ton) of coke at plants which discharge cooling once-through water to one 125 to 625 l/kkg (30 to 150 gal/ton) where cooling water is recycled. Effluent from the light oil recovery plant contains primarily phenol, cyanide, ammonia, and oil.

The quenching of coke requires about 2,100 liters of water per kkg of coke (500 gal/ton). Approximately 35 percent of this water is evaporated by the hot coke and discharges from the quench tower as steam.

A delicate balance is struck in quenching. Most of the fire is quenched, but enough heat should remain in the coke mass to evaporate the water trapped within the coke lumps. Quench station runoffs are collected in a settling basin where coke fines are recovered for other mill uses. The clarified water is recirculated to the quench tower. Evaporative losses, which are obviously quite high, are continuously made up. Past practices have often disposed of contaminated waste waters as make-up to quenching operations, but strong objections from an air pollution standpoint have been voiced. Also, various studies indicate that metal corrosion in the vicinity of quench stations using contaminated make-up is accelerated to the point where replacement costs should actually be charged against this method of eliminating contaminated discharges. Further disadvantages accrue in the blast furnace operations when coke quenched with contaminated waste water is charged to the furnace, increasing the pollution potential of the gas washer waters. Future quenching operations should utilize total recycle of quench wastes, with only fresh water make-ups.

Coke wharf drainage and stock pile runoff constitute a minor but nuisance type pollutant. These areas are generally trenched and the waste waters do not enter a receiving stream.

Table 17 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include ammonia, BOD5, cyanide, oil, phenol, sulfide, and suspended solids.

Beehive Coke Subcategory

General process and water flow schematics of typical beehive coke plants are presented on Figures 4 and 5. The beehive produces only coke and no other by-products are recovered. Water is used only for coke quenching.

Raw waste loads for the beehive will vary due to coking time, water use systems, moisture and volatility of the coal, and carbonizing temperature of the ovens. However, the raw waste is affected most by the type of water use systems, that is once-through or recycle. Test data indicated that with a recycle system, the net plant raw waste loads after quenching are less than the recycled water that is used for quenching. Minimum and maximum values for plant effluents in the study ranged from 0 to 2,040 l/kkg (0 to 490 gal/ton) coke produced.

Table 18 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include ammonia, BOD5, cyanide, phenol, and suspended solids.

Burden Preparation Operation

General process and water flow schematics of typical sintering, pelletizing, and briquetting plants are presented on Figures 6,7,8,9,10 and 11. Only sintering plants were investigated in this study as no pelletizing and briquetting plants are in operation at this time. Several plants are due on line in 1974.

Raw wastes from the sintering process emanate from the material handling dust control equipment and the dust and volatized oil in the process gases. Most plants built today have incorporated fabric type dust collectors in this process. Therefore, newer plants generally have no aqueous discharge from the sintering operation. However, an attempt was made for this study to investigate several plants that utilized wet scrubbers and generated waste water. Another problem that compounds the issue is that the sintering wastewaters are generally tied in with the blast furnace wastewaters for treatment. This will be discussed in more detail in Section VII - Control and Treatment Technology.

The raw waste loads generated from the sintering operation are primarily dependent on the type of fume collection system installed. The fume collection systems are generally divided into two separate independent exhaust systems. One exhaust system serves the hot sinter bed, ignition furnace, sinter bed wind boxes, etc., while the other system serves as a dedusting system for sinter crushes, sinter fines conveyors, raw material, storage bins, feeders, etc.

TABLE 17

Characteristics of By-Product
Coke Plant Wastes
Net Plant Raw Waste Load

Characteristics	Plants A	B	C	D*
Flow, l/kkg	580	530	154	19200
Ammonia, mg/l	1900	1380	7330	39
BOD_5, mg/l	1550	1280	1120	12
Cyanide, mg/l	102	110	91	7.7
Oil and Grease, mg/l	--	240	101	2.1
Phenol, mg/l	450	350	910	6.1
Sulfide, mg/l	--	629	197	4.2
Suspended Solids, mg/l	--	36	421	23

*Concentrations are low due to the addition of the final once-through cooler stream which contained significant cyanide.

TABLE 18

Characteristics of Beehive
Coke Plant Wastes
Net Plant Raw Waste Load

Characteristics	Plants E	F*	G*
Flow, l/kkg	2040	2040	513
Ammonia, mg/l	0.33	0	0
BOD_5, mg/l	3.00	0	0
Cyanide, mg/l	0.002	0	0
Phenol, mg/l	0.011	0	0
Suspended solids, mg/l	---	29	722

*Unless a significant pick-up is found in a given constituent in recycle systems, it is not possible to determine a meaningful net raw waste load.

The sinter bed fume collection and exhaust systems also furnish the necessary combustion air to maintain the coke burning which fuses the sinter mix bed on the moving sinter grates. The ignition furnace initially ignites the coke in the sinter bed and the combustion air maintains the burning of the moving bed. The ignition furnaces are fired by natural gas or fuel oils. The combustion air is drawn down through the sinter bed and hot gases and particulate are then exhausted. Any heavy sinter fines materials falling through the sinter grates are gravity settled in the wind box hoppers are discharged to the sinter fines return conveyor for reprocessing. The combustion exhaust systems require large quantities of air and generally dry electrostatic precipitators are installed at the charge end of sinter machine to clean the hot exhaust gas.

Table 19 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include fluoride, oil, sulfide, and suspended solids.

Blast Furnace Operations

General process and water flow schematics of typical blast furnace operations are presented on Figures 12,13,14 and 15. The typical blast furnace requires:

a. 2 kkg of ore,

b. 0.5 kkg of coke,

c. 0.5 kkg limestone,

d. 3.5 kkg of air,

to produce

e. 1.0 kkg iron,

f. 0.5 kkg slag, and

g. 5 kkg of blast furnace gas.

The blast furnace has two basic water uses, cooling water and gas washer water. The blast furnace requires the continuous circulation of cooling water through hollow plates built into the walls of the bosh and stack. Without such cooling, a furnace wall would quickly burn through. Furnace cooling water approximates 21,000 l/kkg (5,000 gal/ton). The most significant parameter from this source is heat pick-up ranging from 2-8°C.

The principal waste waters result from the gas cleaning operation which is performed for two basic reasons. The primary reason for cleaning the gas is to allow its use as a fuel. The other reason is to prevent a considerable air pollution problem which would otherwise result. Gas washer water may range from 6,300-17,000 l/kkg (1,500 - 4,100 gal/ton) depending upon the type of washer used. These waste waters contain significant concentrations of cyanide, phenol, ammonia, sulfide, and suspended solids. The waste waters from ferromanganese furnaces have much higher concentrations of cyanides than do wash waters from iron furnaces.

The suspended solids in blast furnace gaswasher water result from the fines in the burden being carried out in the gas. The quantities depend upon the operation of the furnace and the nature of the burden. Oils can be vaporized and carried into the gas when metal turnings are part of the charge. Phenols, cyanides, and ammonia originate in the coke and are particularly high if the coke has been quenched with waste waters or if the coke has not been completely coked. Cyanides are generated in the blast furnace in the reducing atmosphere from carbon from the coke and nitrogen from the air; cyanide formation is particularly high at the higher temperatures of a ferromanganese furnace.

Table 20 summarizes the net plant raw waste loads for the iron making blast furnaces studied. Table 21 presents comparable data for the ferromanganese furnace. Raw waste loads are presented only for the critical parameters which include ammonia, cyanide, oil, phenol, and sulfide with manganese added to the ferromanganese furnace.

Steel Making Operations

The steelmaking process produces fume, smoke, and waste gases as the unwanted impurities are burned off and the process vaporizes or entrains a portion of the molten steel into the off-gases. Wastewater results from the steelmaking processes when wet collection systems are used on the furnaces. Spray cooling, quenching, or the use of wet washers result in waste waters containing particulates from the gas stream. Dry collection methods through the use of waste heat boilers, evaporation chambers, and spark boxes do not produce waste water effluents.

Basic Oxygen Furnace Operation

General process and water flow schematics of typical basic oxygen furnace operations are presented on Figures 16,17,18,19 and 20.

The basic oxygen furnace has four main plant water systems:

a. Oxygen Lance Cooling Water System

b. Furnace Trunnion Ring Cooling Water System

c. Hood Cooling Water System

TABLE 19

Characteristics of
Sintering Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants H	J
Flow, l/kkg	434	1420
Suspended Solids, mg/l	4340	19500
Oil and Grease, mg/l	504	457
Fluoride, mg/l	0.644	-14.9
Sulfide, mg/l	188	64.4

TABLE 20

Characteristics of
Fe-Blast Furnace Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants L	M	N	O
Flow, l/kkg	22500	8050	14000	13000
Ammonia, mg/l	1.41	3.91	9.75	12.3
Cyanide, mg/l	1.44	0.858	-0.241	-0.231
Phenol, mg/l	0.578	-0.643	0.530	0.0853
Suspended Solids, mg/l	1720	651	307	1170
Fluoride, mg/l	0.454	0.044	2.16	-2.59
Sulfide, mg/l	4.34	38.8	0.448	-1.14

d. Fume Collection Cooling Water System

The oxygen lance cooling water system is either a "once through" or a "closed recirculating" system. The resultant aqueous discharge from the "once through" system is heated cooling water, generally with a differential temperature increase of 11-17°C. The water rate of these systems range from 30-93 l/sec (7.9 - 25 gal/sec).

The aqueous discharges from the "closed system" is the heated cooling water used on the tube side of the shell and tube heater changes. This cooling water can either be once through or can be interconnected with the hood cooling water system. Water rates and temperature rises are in the same range as the "once through" system.

The furnace trunnion ring cooling water system is generally a "once through" system with an aqueous discharge of heated water with a differential temperature increase of 22°C. These cooling systems are being added to existing shops in order to reduce the thermal stresses and warping of the heavy fabricated steel plate trunnion rings. Water rates range 13-26 l/sec (3.2 - 6.1 gal/sec) continuous rate.

The hood cooling water system depends upon the type of hood equipment selected for the process. Basically, there are three types of hoods, water cooled plate panel, water tube hood, or steam generating hood. The hoods serve as combustion chambers as well as means for conveying the combusted gases to the fume collection system. As the pure oxygen is blown above the molten iron bath, the carbon in the bath is oxidized to carbon monoxide (CO) which is emitted from the furnace mouth. Since the gases approximate temperatures of 1,540-1,590°C and come in contact with air above the furnace and at the hood mouths combustion will occur, hence the CO gases are burned to CO2.

The water cooled plate panel hood cooling water system is generally a recirculating type using induced draft cooling towers with chemical treatment. The water rates for these hoods vary from 320-950 l/sec (84 - 260 gal/sec) with water temperature increase of 11°C to 17°C. Make-up water is added to the system to compensate for cooling tower blowdown, evaporation loss and panel leakage. These systems operate under a relatively low water pressure of 4 to 8 atmospheres. If good quality and water quantity is available, "once through" cooling systems are sometimes employed. Plate panel hoods are fabricated in independent panels of sandwich construction for the water passageways and are grouped together to form a hood. The panels are relatively loose-fitting and therefore afford greater air leakages into the fume collection systems.

The water tube hood is of gas-tight construction fabricated from heavy walled tubing. These hoods can be operated at higher water pressures and temperatures than the plate panel hoods. The water cooling systems for these hoods are generally "closed recirculating" using induced draft cooling towers or if operating at high pressures, evaporative coolers and heat exchangers are used. The pressures vary from 8 atmospheres to 18 atmospheres. These types of hoods are used with the special type fume collection system identified as "OG" or "OFF-GAS" system. In this type of fume collection system, the hood is capped tightly on the furnace mouth, thus preventing combustion of CO gases. The aqueous discharge from this system would be blowdown, or heated cooling water if "once through" cooling were used.

The steam generating hoods are high pressure waste heat boilers which used the combustion heat for generating steam. These systems operate in a range of 28 to 62 atmospheres steam. Only about 22% of the heat generated is used in steam generation, but some plants have additional economizer sections for greater heat transfer efficiency. The aqueous discharge from the steam generator hood is boiler blowdown. Some plants install steam accumulators to even out the cyclic steam production rate while others condense the steam in air/water heat exchangers and recirculate.

The type of fume collection system and hood cooling system selected is not only dependent upon capital cost but also equated on other plant characteristics such as operating costs, plant location, availability of resources (power, water, etc.), and available pollution abatement equipment (such as existing central water treatment facilities), etc.

The fume collection systems can range from a complete dry precipitator to semi-wet to wet high energy venturi scrubber systems. Each particular fume collection system has advantages in relation to the plant characteristics.

The dry type precipitator system usually employs a steam generating hood equipped with a refractory lined evaporation chamber. The aqueous discharge from this fume collection system is zero except for hood blowdown. As the hot gases (1,300°C) exit from the steam generating hood, water sprays condition the gas temperature to 260°C at the evaporative chamber outlet. The evaporation chamber (approximately 9 m diameter x 18 m high) (approximately 10 x 20 yds) provides the required retention time to allow the water sprays to evaporate and mix with the hot gases and reduce the temperature. The precipitator system requires a minimum of 100% excess air be introduced in the system to insure minimum non-combusted CO carryover to precipitators. Generally, these systems will yield a 1-2% CO content in the exhaust gases. The semi-wet system employs a precipitator too, except the gases are conditioned to 260°C by means of a spark box spray chamber. The spark box spray chamber utilized an excessive spray water system. The retention time is much less in the spark box. Therefore, in order to condition the gases to the proper temperature, more water is sprayed into the system than can be evaporated. This results in an aqueous discharge from the spark box. Generally, plate panel hoods with 200-300% excess air are employed with these systems. These systems are less capital cost than steam generating with spray chambers.

The aqueous discharge is hot water ranging in temperature from 82-88°C and containing suspended solids of iron oxides (Fe_2O_3, FeO) and fluxing materials, lime, etc.

An alternate system to the spark-box spray or dry evaporation chamber system is to install a wetted wall type evaporation chamber. A wetted wall evaporation chamber contains no refractory lining, but uses a water wetted steel surface as the heat resistant medium. These chambers require large quantities of water to insure that the steel surfaces do not become overheated.

The wet high energy venturi scrubber fume collection systems generally use steam generating type hoods close coupled with a low energy fixed orifice quencher. As the hot gases exit from the hood, the gases are immediately quenched from 150°C to 83°C.

The gases are hotter exiting from the hood on a wet scrubber system because the maximum excess air admitted to the system is approximately 50% versus the 100-200% for precipitator systems.

The reasons for this are to reduce hp consumption and still maintain a minimum residual of CO in fume collection gases. Sometimes to further reduce wet fume collection system horsepower requirements, large self-contained cooling towers are added to the system to reduce the gas temperatures further from 83°C saturated to 43°C saturated. As the gases are saturated, the cooling is accomplished by strictly gas to water contact and heat transfer.

The cooling towers are checker brick lined enclosed cylindrical steel towers 9 m in diameter by 24-27 m high (approximately 10 by 28 yds). As these cooling systems are installed on the clean gas side of the venturi scrubbers, the cooling waters are recycled after passing through remote induced draft cooling towers with chemical treatment. Make-up water is added to compensate for evaporation loss, blowdown, cooling tower drift, etc.

These systems could be "once through" if quantities of clean water are available.

An alternate wet system to the venturi scrubber system is the wet gas washer and disintegration system. This system has a limited use due to the large volume and horsepower required to operate the disintegrator. Disintegrators operate in the range of 154 to 1,820 cu-m/min (5,440 to 65,000 cu ft/min) at 450 kw which would require six to seven units for an average 180 kkg (200 ton) basic oxygen furnace.

The off gas system uses this similar quencher and venturi scrubber similar to the open hood combustion type system. The OG system is a sealed system for handling CO gases. The gases are either flared (burned) at the outlet stack or stored for fuel purposes. The CO gas heating value is 19,800 kg cal/ cu m (554 kg cal/cu ft).

Efficiency wise, it is more conducive to collect the CO and fire a standard boiler (80% efficiency versus 22%) rather than the waste heat steam generating hoods.

Table 22 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include fluoride and suspended solids.

Open Hearth Furnace Operation

General process and water flow schematics of open hearth operations are presented on Figures 21,22 and 23.

The open hearth process has two plant water systems:

a. Furnace cooling

b. Fume collection water system

The furnace cooling water ssystems are generally limited to the furnace doors. These systems are "once through" cooling systems with heated aqueous discharges of 17-22°C differential temperature.

Either wet high energy venturi scrubber systems or dry precipitator systems are installed on open hearth shops. The hot gases to the precipitator systems are conditioned by either passing the gases through evaporation chambers or through waste heat boilers, reducing the gas temperature from 870°C to 260°C. Because the open hearth furnaces are fired using many available fuels, nitrous oxides and sulfur oxides are present in the waste gas streams.

The aqueous discharges from precipitators are zero except for any waste heat boiler blowdown.

The aqueous discharges from the high energy venturi scrubber system are scrubbing waters from the primary quenchers.

Table 23 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include fluoride, nitrates, suspended solids, and zinc.

Electric Arc Furnace Operation

TABLE 21

Characteristics of
Fe-Mn Blast Furnace Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plant Q
Flow, l/kkg	32200
Ammonia, mg/l	114
Cyanide, mg/l	23.6
Phenol, mg/l	0.130
Suspended Solids, mg/l	5000
Sulfide, mg/l	-2.66
Manganese, mg/l	833

TABLE 22

Characteristics of
BOF Steelmaking Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants				
	R	S	T	U	V
Flow, l/kkg	542	4270	2570	3040	1080
Fluoride, mg/l	-	-	10.9	2.36	2.76
Suspended solids, mg/l	321	180	3730	396	5330

TABLE 23

Characteristics of Open Hearth
Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants	
	W	X
Flow (l/kkg)	2530	2290
Suspended solids, mg/l	388	3880
Fluoride, mg/l	21.4	16.2
Nitrate, mg/l	20.2	33.2
Zinc, mg/l	2.06	880

General process and water flow schematics of electric furnace operations are presented on Figures 24,25,26 and 27.

The electric furnace has two main plant water systems:

a. Electric Arc Furnace door, electrode ring, roof ring, cable and transformer cooling water system.

b. Fume collection colling water system.

The Electric Arc Furnace cooling water systems for the roof ring, electrode ring, and door cooling is generally a "once through" system but can be a "closed recirculating" system. The resultant aqueous discharge from these cooling systems is heated cooling water, generally with a temperature increase of 17-22°C.

The type of cooling water systems applied to the electric arc furnace are dependent on furnace size. The smaller tonnage furnaces do not have roof ring cooling, door cooling, etc. The type of fume collection and hood exhaust system is not only dependent upon capital cost but also equated on other plant characteristics such as operating cost, plant location, availability of resources (power and water), and available pollution abatement facilities. The fume collection systems range from a complete dry to semi-wet to wet high energy venturi scrubbers. Each system has advantages in relation to plant characteristics.

The dry fume collection system consists of baghouses with local exhaust or plant rooftop exhaust hoods. The aqueous discharges from these systems are zero. The local hoods are located at the sources of fume generation (door, electrode openings, etc.). Enough cooling air is drawn into the hoods to temper the hot gases for a baghouse operation, to approximately 135°C. The rooftop exhaust system exhausts the entire furnace shop.

The semi-wet system employs a spark box or spray chamber to condition the hot gases for either a precipitator or baghouse. A spark box is generally used with a precipitator system and a spray chamber for a baghouse system. The spark box conditions the gases to 200°C while spray chamber conditions gases to 135°C. The aqueous discharge from these systems is controlled and treated with similar systems as used on the spark box chamber on the basic oxygen furnaces. A water cooled elbow is used as the exhaust ductwork and is directly connected to the electric furnace roof. The aqueous discharge from the water cooled elbow is heated cooling water. The systems are generally "once through" with temperature differential of 17-22°C in cooling waters.

The wet high energy venturi scrubber fume collection systems use the water cooled elbow for extracting the gases from the electric arc furnace. Combustion air gaps are always left between the water cooled elbow and fume collection ductwork to insure that all the CO gas burns

TABLE 24

Characteristics of
Electric Furnace Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants Y	Z	AA	AB
Flow, l/kkg	406	1.01	1250	751
Fluoride, mg/l	-28.7	-	14.8	11.3
Suspended Solids, mg/l	863	77.4%	2160	42800
Zinc, mg/l	13	-	405	5637

TABLE 25

Characteristics of
Degassing Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants AC	AD
Flow, l/kkg	3750	813
Suspended Solids, mg/l	23.2	70.7
Zinc, mg/l	2.01	7.76
Manganese, mg/l	5.72	13.3
Lead, mg/l	0.471	1.39
Nitrate, mg/l	25.3	3.03

TABLE 26

Characteristics of
Continuous Casting Plant Wastes
Net Plant Raw Waste Loads

Characteristics	Plants AE	AF
Flow, l/kkg	17100	6172
Suspended Solids, mg/l	7.87	74.0
Oil and Grease, mg/l	20.5	22.0

to CO_2 before entering the high energy venturi scrubber or any other fume collection cleaning device. As the hot gases pass through the scrubber, the gases are conditioned and cooled to 83°C. An aqueous discharge is produced that is similar to the basic oxygen waste water.

Table 24 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include fluoride and suspended solids.

Vacuum Degassing Subcategory

A general process and water flow schematic of the typical vacuum degassing operation is presented on Figure 28. The vacuum degassing process has two main water systems:

a. Flange cooling water system

b. Barometric condenser cooling water system

The vacuum degassing flange cooling water systems are generally "once through" cooling systems, with differential temperature increases of 14°C at an approximate cooling water rate of 12.5-25 l/sec (3-6.1 gal/sec). The RH and DH vacuum degassing vessels have removable flanged roofs for installation of new refractory linings when relined. The flange cooling water aids in preventing warping of these flanges.

The barometric condenser cooling water system is direct process contact cooling where the water is used to condense the steam ejector exhausted steam and gases that are emitted from the molten steel. The vacuum produced in the degassing operation is by means of multi-stage steam jet ejectors producing pressure down to 0.064 atmosphere. The degassing operation removes hydrogen, carbon and oxygen as carbon monoxide plus any volatile alloys in the steel and some iron oxide particulate. After degassing, deoxidizers and/or alloys are added to the molten steel bath to adjust chemistry to the steel specifications.

Table 25 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include lead, nitrate, manganese, suspended solids, and zinc.

Continuous Casting Subcategory

A general process and water flow schematic of the typical continuous casting operation is presented on Figure 29.

The continuous casting process has three main plant water systems:

a. Mold cooling water system

b. Machinery cooling water system

c. Spray cooling water system

The mold cooling water system is generally a tight "closed recirculating" noncontact system using heat exchangers or evaporative coolers as the cooling equipment. The cooling water differential temperature rise is held to approximately 6°C to maintain minimum differential thermal expansion of the mold. A surge tank is installed in the systems for addition of potable water make-up and/or chemical treatment.

The casting molds are copper material, chrome plated and perform the function of solidifying a hard skin around the molten steel as it passes through the mold into the final spray cooling section. There is no blowdown for the closed system.

The machinery cooling water system is generally an "open recirculating" noncontact system using induced draft cooling towers with chemical treatment as cooling equipment. The cooling water differential rise across the machinery is approximately 14°C. The cooling side of the heat exchangers of the mold cooling system is generally tied into the machinery cooling water system.

The aqueous discharge from the machinery cooling water system is cooling tower blowdown. The machinery cooling water system furnishes cooling for the casting machinery (rolls, etc.) spray chamber cooling plate panels, cut-off torch cooling, etc.

The spray cooling water system is a direct contact water spray cooling of the cast product. As the cast product (slabs, blooms, or billets) emerge from the molds, the waste sprays further cool and harden a thicker skin of the cast product.

Table 26 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include oil and suspended solids.

<u>Ingot Casting</u>

A general process schematic of the operation entailed in ingot casting is presented on Figure 30. Generally, the only water usage associated with ingot casting is the spray cooling of the ingot molds in the mold preparation and cleaning area.

The hot molds are sprayed with water to cool them and at the same time knock off minor amounts of scale adhering to the mold surfaces. The majority of the water used is evaporated in contacting the mold. Any excess spray water, which is usually very minor, falls to the ground where it generally evaporates or permeates into the ground. Since this water is generally good quality mill water containing relatively heavy fractions of scale, which collects on the surface of the ground, its permeation into the ground cannot be considered a source of pollution.

The excess spray water contacting the ground is generally so minor that there is rarely, if ever, sufficient volume to cause an overland runoff from the area. If a runoff problem were to exist from excessive spraying of the molds, any potential pollution problems, which would be confined to suspended scale particles, could be better resolved by tightening up on spray water usage rather than by providing treatment for the runoff.

Pig Casting

As in the case of ingot casting, the only water usage associated with pig casting is for mold cooling.

As in the case of ingot casting, excess spray water is so minimal that there is rarely sufficient volume to run off from an area. Excess spray water falls to the ground where it either evaporates or permeates into the ground. Since lime is used as a mold release agent in the pig casting process, this minor excess water may be slightly alkaline. However, the excess water is of such small volume and alkalinity so slight, that the pollution potential of this stream is negligible.

As in the case of ingot casting, where significant runoffs from the pig casting area occur, they could best be handled by tightening up on spray water usage.

Slagging

Hot blast furnace slag is usually dumped into a large pit, open at one end, to enable removal after quenching and quenched and cooled to a temperature at which it can be transported relatively safely to a final disposal site or a slag processing plant.

During quenching of the slag, there is little or no actual runoff from the site, the great majority of the water being evaporated. As the slag temperature is lowered, however, some excess quench water will remain unevaporated. The quench pits are normally graded so that this excess water will collect in the bottom of the pit rather than run off overland from the site. Once the cooled slag is removed for final disposal, the pooled water laying in the bottom of the quench pit will remain and be flashed off by the next hot slag charge.

However, during this period of slag cooling, some of the excess quench water may permeate into the ground, thus constituting a subsurface discharge.

Samples of pooled quench water after contact with the slag, indicate that this is a highly alkaline (1,067 mg/l M.O. Alkalinity) waste water, low in suspended matter, but high in dissolved solids probably in the form of calcium and magnesium sulfates, sulfides, and sulfites (890 mg/l $SO_4^=$, 499 mg/l S^-, and 1,560 mg/l SO_3^-). The main source of the alkalinity is probably calcium carbonate leached out of the slag.

Although the actual amounts of undesirable contaminants permeating into the ground is highly variable, depending upon the amount of excess quench water used, the time any pooled water may be allowed to permeate, and the general soil permeability at the quench site, certain conditions might produce undesirable subsurface discharges.

These potentially undesirable discharges could be eliminated if these quench pits were to have an impermeable lining such as concrete or some other suitable material. Excess quench waters would then remain in the quench pit until such time as they are evaporated by the next hot slag charge. In fact, concrete-lined slag pits do exist at some plants where the slag quench station is in the immediate vicinity of the blast furnace. This is done in order to prevent soil removal during quench pit cleaning and possible weakening of the blast furnace foundation.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

Introduction

The selection of the control parameters was accomplished by a three step process. First a broad list of polluted parameters to be tested for was established. Second, the list of anticipated control parameters and procedures for check analyses of these critical parameters was established. Thirdly, the data from the field sampling program was evaluated to establish the need to deviate from the anticipated list based on the field experience.

Broad List of Pollutants

Prior to the initiation of the plant visiting and sampling phase of the study it was necessary to establish the list of pollutant parameters that was to be tested for in each type of waste source. These parameters were selected primarily on the basis of a knowledge of the materials used or generated in the operations and on the basis of pollutants known to be present as indicated by previously reported analyses. The purpose of the broad list was to identify those pollutants present in a significant amount but not normally reported or known to be present to such an extent. The parameters that may be present in steel industry waste water streams are presented in table form by operations as follows:

Table 27 - Coke Making Operations
Table 28 - Sintering Subcategorys
Table 29 - Blast Furnace Operations
Table 30 - Steel Making Operations
Table 31 - Vacuum Degassing Subcategorys
Table 32 - Continuous Casting Subcategorys

Rationale for Selection of Control Parameters

On the basis of prior analyses and experience the major waste water parameters that are generally considered of pollutional significance for the raw steel making operations of the iron and steel industry include ammonia, BOD_5, cyanide, phenol, oil and grease, suspended solids and heat. Other parameters, such as chloride, are present in significant amounts but were not established as control parameters because their presence in the effluent is not as significant and the cost of treatment and technology for removal in these operations is considered to be beyond the scope of best practicable or best available technology. In addition, some parameters cannot be designated as control parameters until sufficient data is made available on which to base effluent limitations or until sufficient data on treatment capabilities is developed.

The concentration of iron appearing in the effluent is a function of the chemical form in which it is present and on the pH and temperature of the effluent. In the raw steel making operations the iron is present in the very insoluable oxide form and on this basis soluble iron did not need to be establised as a control parameter for these operations. The suspended solids limitations places a limit on the iron present insoluble form.

Standard raw waste loads and guidelines are developed only on the critical parameters which were starred in the tables. Multiple analyses of these anticipated control parameters was provided for to give added accuracy to the data.

Selection of Additional Control Parameters

The plant studies indicated that consideration should be given to including additional parameters as control parameters in certain subcategories because of the quantities found or likely to be present and the pollutional significance of the material. These parameters are enumerated in their respective subcategories and include sulfide, fluoride, nitrate, zinc, lead, and manganese.

Selection of Critical Parameters by Operation

The rationale for selection of the major waste parameters for the steel industry is given below. The rationale for selection of the major waste parameters for the steel industry is given below.

Coke Making Operations

The principal liquid wastes in coke making originate from the ammonia liquor, coke quenching effluents, benzol plant decant waters and final cooler waters. These waste streams contain phenols, cyanide, BOD5, ammonia, sulfide, suspended solids, and oil.

Sintering Subcategory

The dust produced from the sintering plant operation is frequently recovered through the use of wet washers operating on the exhausts of hoods and building ventilators. This wastewater is produced as a result of air pollution abatement measures and occupational health and safety precautions. These waste waters may contain significant amounts of suspended matter, oil, sulfide, and fluoride. The source of these contaminants is dependent upon the variety of materials that are a part of the sinter mix.

Iron Making Operations

The principal waste waters sources from the blast furnace operation are waters used in washing the exit gases free of suspended matter and noncontact cooling of the blast furnace hearth and shell. The gas is also cleaned to allow its use as a fuel. In addition to furnace operating conditions, a carryover in the coke may also result in pollutants that were prevalent in the coke making waste waters. Therefore, iron making blast furnace waste waters may contain ammonia, cyanide, phenol, suspended solids, and sulfide. The ferromanganese furnace will contain manganese in addition to the normal parameters inherent in the typical iron making furnace.

Steelmaking Operations

The waterborne wastes from the steelmaking operations result from scrubbing of the gas stream with water to prevent air pollution and for noncontact cooling. Hence, basic oxygen and electric furnace waste waters may contain suspended solids and fluorides. Fluorspar, one of the basic raw materials in steelmaking, is the source of fluorides. The open hearth, due to the nature of its scrap mix will also contain zinc and nitrates may result due to the huge volumes of excess air that is used to provide better combustion.

Vacuum Degassing Subcategory

In the vacuum degassing process, steel is further refined by subjecting the steel in the ladle to a high vacuum in an enclosed refractory lined chamber. Steam jet ejectors with barometric condensers are used to draw the vacuum. In the refining process certain alloys are added which may be drawn into the gas stream. In addition, the system is purged with nitrogen so as to have no residual CO. Therefore, the wastewater products from this operation are condensed steam and waste water containing suspended solids, zinc, manganese, lead, and nitrates.

Continuous Casting Subcategory

Wastewaters from the continuous casting operations result from washing scale from the surface of the steel with spray water. Therefore, continuous casting waste waters may contain significant quantities of suspended matter and oil. The mold cooling and machine cooling systems are usually closed systems and the water picks up only heat.

TABLE 27

I. COKE MAKING - BY PRODUCT OPERATION

II. COKE MAKING - BEEHIVE OPERATION

PARAMETERS

Acidity (Free and Total)
Alkalinity (Pht. and M.O.)
*Ammonia
Berylium
*BOD5
Chloride
COD
Color
*Cyanide, Total
Dissolved Solids
*Flow
Heat
Mercury
Nitrogen, Kjeldahl
*Oil and Grease
*pH
*Phenol
Sulfate
*Sulfide
*Suspended Solids
Thiocyanate
TOC
Total Solids
Turbidity
T.O.N.

TABLE 28

III. SINTERING OPERATION

PARAMETERS

Acidity (Free and Total)
Alkalinity (Pht. and M.O.)
Aluminum
Berylium
Chloride
COD
Color
Dissolved Solids
*Flow
Fluoride
Hardness, Total
Heat
Iron, Total
Manganese
Mercury
*Oil and Grease
*pH
Phosphorus, Total
Potassium
Sodium
Sulfate
*Sulfide
*Suspended Solids
TOC
Total Solids
T.O.N.

*Indicates parameters on which standard raw waste load was developed.

TABLE 29

IV. BLAST FURNACE - IRON MAKING OPERATION

V. BLAST FURNACE - FERROMANGANESE OPERATION

PARAMETERS

Acidity (Free and Total)	Nitrate
Alkalinity (Pht. and M.O.)	Nitrogen, Kjeldahl
Aluminum	Oil and Grease
*Ammonia	*pH
Berylium	*Phenol
BOD_5	Phosphorus, Total
Chloride	Potassium
COD	Sodium
*Cyanide, Total	Sulfate
Dissolved Solids	*Sulfide
Flow	*Suspended Solids
Fluoride	Thiocyanate
Hardness, Total	TOC
Heat	Total Solids
Iron, Total	Color
**Manganese	T.O.N.

*Indicates parameters on which standard raw waste load was developed.

**Indicates additional parameter on ferromanganese furnace.

TABLE 30

VI & VII. BASIC OXYGEN FURNACE OPERATION

VIII. OPEN HEARTH FURNACE OPERATION

IX & X. ELECTRIC ARC FURNACE OPERATION

PARAMETERS

Acidity (Free and Total)	Mercury
Alkalinity (Pht. and M.O.)	**Nitrate
Aluminum	Oil and Grease
Color	*pH
Copper	Phosphorus, Total
Dissolved Solids	Silica, Total
*Flow	Sulfate
*Fluoride	Sulfide
Hardness, Total	Sulfite
Heat	*Suspended Solids
Iron, Total	Total Solids
Lead	**Zinc
Manganese	T.O.N.

*Indicates parameters on which standard raw waste load was Developed.

**Indicates additional parameters on open hearth steelmaking.

TABLE 31

XI. VACUUM DEGASSING OPERATION

PARAMETERS

Acidity (Free and Total)	Mercury
Alkalinity (Pht. and M.O.)	*Nitrate
Aluminum	Oil and Grease
Color	*pH
Copper	Phosphorus, Total
Dissolved Solids	Silica, Total
*Flow	Sulfate
Fluoride	Sulfide
Hardness, Total	Sulfite
Heat	*Suspended Solids
Iron, Total	Total Solids
*Lead	*Zinc
*Manganese	T.O.N.

TABLE 32

XII. CONTINUOUS CASTING OPERATION

PARAMETERS

Acidity (Free and Total)	Mercury
Alkalinity (Pht. and M.O.)	Nitrate
Aluminum	*Oil and Grease
Color	*pH
Copper	Phosphorus, Total
Dissolved Solids	Silica, Total
*Flow	Sulfate
Hardness, Total	Sulfide
Heat	Sulfite
Iron, Total	*Suspended Solids
Lead	Total Solids
Manganese	Zinc
T.O.N.	

*Indicates parameter on which standard waste load was developed.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

Introduction

Plant studies were conducted in each subcategory at plants that were deemed to be the best relative to performance levels attained by their treatment facilities. The plants visited were selected by the EPA from the candidate plants listed in Table 15. Table 33 presents a brief summary of treatment practices employed at all plants visited in this study and shows the variability of treatment techniques employed in the industry. Included in each subcategory are tables presenting the size, location, and ages of the plants that were visited.

Range and Permutations of Treatment Technology and Current Practice as Exemplified by Plants Visited During the Study

In each subcategory, a discussion is presented on the full range of technology employed within the industry followed by a discussion on the treatment practices, effluent loads, and reduction benefits at the plants that were visited. The effluent is stated in terms of gross plant effluent waste load.

Coke Making-By Product Operation

A variety of methods for treating coke plant wastes has been practiced in the past, changing under the influence of economic conditions, and increasing restrictions on effluent quality. The recovery of sodium phenolate, ammonium sulfate or phosphate, and light oils has become unprofitable for most coke plants in the face of competition from other industries, primarily petro-chemical. But at the same time, the need to recover increasing amounts of these and other materials present in the waste water has greatly increased if the plants expect to comply with the effluent standards required to upgrade stream conditions. Processes designed to recover percent quantities of pollutants may not be effective in reducing waste loads to minute fractions of a pound per ton of coke produced, or fractions of a milligram per liter of water discharged.

Various degrees of treatment, usually in the form of by products recovery, have been practiced at different coke plants. In addition, other techniques will need to be developed and perfected to remove objectionable parameters from wastes prior to discharge to streams. An ultimate goal would be the total elimination of liquid wastes which have contacted dirty gas streams, provided that no detrimental effects on air or land use occur. A summary of the control and treatment technology practiced for the by-product operations follows:

TABLE 33

Wastewater Treatment Practices of Plants Visited in Study

Plant	Practice
I. Coke Making	
By-Product	
A	Waste ammonia liquor, light oil wastewaters and final cooler wastewaters treated via ammonia stripping and solvent recovery, followed by discharge to receiving stream.
B	Waste ammonia liquor treated via activated sludge aeration system and clarification, followed by discharge to receiving stream. Final cooler and benzol plant wastewaters sent to coke quenching for complete evaporation.
C	Waste ammonia liquor treated via solvent recovery, ammonia stripping, and settling followed by discharge to sanitary authority. Final cooler and light oil wastewaters sent to coke quenching for complete evaporation.
D	Waste ammonia liquor treated via detarring, solvent recovery, and ammonia stripping, followed by discharge to receiving stream. Once-through final cooler (indirect cooling) wastewaters discharged directly without treatment.

PLANT	PRACTICE
II Coke Making	
Beehive	
E	Coke quench wastewaters treated via settling, followed by discharge to receiving stream.
F	Coke quench wastewaters treated via settling and complete recycle. No aqueous discharge to receiving stream.
G	Coke quench wastewaters treated via settling and complete recycle. No aqueous discharge to receiving stream.
III Burden Preparation	
Sintering	
H	Sinter plant wet scrubber wastewaters combined with blast furnace and other unidentified wastewaters and treated via chemical coagulation and thickening, followed by discharge to receiving stream.
I	Sinter plant wastewaters combined with blast furnace gas cleaning system wastewaters and treated via thickening alkaline chlorination, sand filtration and recycle with blowdown. Blowdown is discharged to receiving stream.
J	Sinter plant scrubber system wastewaters combined with underflow from blast furnace treatment system thickener and treated via thickening. A portion of the thickener overflow is blown down to a sanitary authority, while the majority is passed through a cooling tower and recycled for reuse.

Plant	Practice
Sintering (Cont'd.)	
K	Sinter plant scrubber system wastewaters combined with underflow from six blast furnace thickeners and treated via thickening. Thickener overflow is combined with BOF treatment system overflow and treated via clarification. Clarifier overflows are then stored in settling ponds where the water is recycled with blowdown.
IV Blast Furnace Iron Making	
L	Blast furnace gas cleaning system wastewaters are combined with sinter plant wastewaters and treated via thickening, alkaline chlorination, filtration and recycle with blowdown to a receiving stream.
M	Blast furnace gas cleaning system wastewaters are treated via thickening. A portion of the thickener overflow is blown down to a sanitary authority while the majority is passed through a cooling tower and recycled for reuse.
N	Blast furnace gas cleaning system wastewaters treated via thickening, evaporative cooling, and recycle with blowdown. Blowdown is used for slag and coke quenching and BOF hood sprays and is completely evaporated. No aqueous discharge to a receiving stream.

Plant	Practice
Fe Blast Furnace (Cont'd.)	
O	Blast furnace gas cleaning system wastewaters are treated via thickening, evaporative cooling, and recycle with blowdown. Blowdown is used for slag and coke quenching and BOF hood sprays and is completely evaporated. No aqueous discharge to a receiving stream.
P	Blast furnace gas cleaning system wastewaters treated via thickening followed by complete recycle. No aqueous discharge to a receiving stream.
V Blast Furnace Ferromanganese	
Q	Venturi scrubber wastewaters treated via thickening and complete recycle to the scrubbers. Gas cooler wastewaters discharged to a receiving stream without treatment.
VI, VII Basic Oxygen Furnaces	
R	Gas cleaning system wastewaters treated via chemical coagulation, settling, followed by a complete recycle. No aqueous discharge to a receiving stream.
S	Gas cleaning system wastewaters treated via thickening, followed by recycle with blowdown to a receiving stream.
T	Gas cleaning system wastewaters treated via classification, thickening, followed by recycle with blowdown.

Plant	Practice
Basic Oxygen (Cont'd.)	
U	Gas cleaning system wastewaters treated via chemical coagulation, thickening, and discharge to a receiving stream.
V	Gas cleaning system wastewaters treated via chemical coagulation, thickening, followed by recycle with blowdown to a receiving stream.
VIII Open Hearth Furnaces	
W	Gas cleaning system wastewaters treated via thickening and recycle with blowdown to a receiving stream.
X	Gas cleaning system wastewaters treated via chemical coagulation, thickening, and recycle with blowdown to a receiving stream.
IX, X Electric Furnaces	
Y	Gas cleaning system wastewaters treated via chemical coagulation, magnetic flocculation, and sedimentation followed by total recycle with no discharge of process wastewaters.
Z	Closely controlled moisture addition to gas cooler allows cooler effluent to be in the form of a heavy sludge. Sludge collected in tank and removed for disposal. No aqueous discharge to a receiving stream.
AA	Gas cleaning system wastewaters treated via classification and clarification, followed by discharge to a receiving stream.

Plant	Practice
Electric Furnace (Cont'd.)	
AB	Blowdown from gas cleaning water recycle system is treated via thickening and extended settling, followed by discharge to a receiving stream.
XI Vacuum Degassing	
AC	Vacuum degassing wastewaters combined with non-contact BOF cooling waters, a portion blown down to a receiving stream, and the remainder passed through a cooling tower before reuse. Thus, no treatment of raw wastewaters prior to blowdown.
AD	Degassing wastewaters combined with continuous caster wastewaters and treated via settling, filtration, evaporative cooling and recycle with blowdown to a receiving stream.
XII Continuous Casting	
AE	Wastewaters treated via settling, filtration, followed by recycle with blowdown to a receiving stream. A portion of the recycled water is subjected to evaporative cooling before reuse.
AF	Continuous caster wastewaters combined with degasser wastewaters and treated via settling, filtration, evaporative cooling and recycle with blowdown to a receiving stream.

a. A first attempt at recovery usually practiced at older by-product coke plants has been the stripping of ammonia from the raw ammoniacal liquor through the use of steam in an ammonia still. Other volatile compounds, including hydrogen sulfide, hydrogen cyanide, and carbon dioxide are simultaneously liberated from the liquor and returned to the gas stream. In most cases, this causes higher sulfide and cyanide levels elsewhere in the system, for example the final coolers. The stripped liquor still contains significant amounts of ammonium salts, the so called fixed ammonia.

b. By-products recovery systems usually contain dephenolization in some form or other, although recently, many plants have abandoned efforts to market their sodium phenolates. The most common dephenolization techniques include vapor recirculation, where the steam leaving the free leg of the ammonia still is scrubbed with a dilute caustic soda solution to recover sodium phenolate. The steam recirculates and the dephenolized liquors may be further treated in the ammonia stills. The other most widely phenol recovery technique is a liquid/liquid extraction using solvent such as benzol or light oil. The phenol-carrying solvent is then extracted with caustic, the sodium phenolate separates, and the solvent is reused in the dephenolizer. The treated liquor is again available for discharge or further treatment.

c. A third step in reducing waste discharges to the stream practiced by most companies is the recycling of all quench station wastes, eliminating liquid discharges from this source. The practice was first made necessary by the use of contaminated water as quench tower make-up, but should be continued, even where fresh water make-ups are used.

d. Additional flow reductions are accomplished by closing up the final cooler systems, passing these discharges over cooling towers or through a spray pond for recycling. This practice significantly decreases the discharge of cyanides and sulfides to the streams.

e. Since only about half of the ammonia from the still wastes can be recovered in the free leg of an ammonia still, processors began to add a milk of lime slurry to the dephenolized waste and passed it through a second leg of the ammonia still for additional steam stripping. This effectively liberates most of the remaining fixed ammonia to the gas stream for recovery in the absorber. The de-ammoniated liquor is transferred to a settling pond to provide for separation of solids.

f. Despite the above recovery techniques, residual concentrations of contaminants may still be too high to be acceptable for discharge. In recent years, these systems have been improved in a variety of ways:

1. The construction of in-plant biological treatment plants utilizing large, aerated lagoons and bacterial cultures specifically acclimated to break down phenols, cyanides and/or ammonia into non-toxic products.

2. Provision of sufficient pre-treatment of by-product coke plant wastes to render them acceptable for treatment in municipally-owned sewage treatment plants.

3. Distillation and incineration of the total coke plant waste load in carefully controlled combustion systems. No by-products other than coke oven gases are recovered and no liquid effluents are discharged.

4. Improved solvent extraction techniques for recovery of more phenolics through the use of more selective solvents.

g. Additional research is continuing on new treatment methods and their possible applications to coke plant wastes:

1. Development of improved biological systems. Systems currently in use preferentially eliminate one or two of the objectionable trace materials left after other treatment methods, while tolerating fairly high concentrations of other pollutants. The biological degradation of these materials is possible, also.

2. Oxidation using ozone, chlorine compounds or other strong oxidants is receiving considerable attention. Past efforts have been disappointing when attempted on raw waste waters, but are worth investigating as a polishing technique after gross quantities are removed by more conventional methods.

3. Carbon absorption has been utilized to treat chemical and refinery wastes which are quite similar to by-product coke plant wastes. The technique is widely used on large volume flows, and should be considered potentially applicable to coke plant problems.

Plant Visits

Four by-product coke plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 33 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

Plant A - Figure 32

Once-through system. Light oil and weak ammonia liquor waste waters are treated with ammonia stills or free leg and proprietary solvent extraction. Direct discharge of ammonium sulphate crystallizer effluent.

Normal gross plant effluent waste load is estimated at 650 l/kkg of coke (153 gal/ton) flow, and 0.61 kg ammonia, 0.042 kg BOD5, 0.062 kg cyanide and 0.00087 kg phenol per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia, BOD5, cyanide and phenol are 44.6%, 95.4%, 89.6%, and 99.6% respectively.

Plant B - Figure 33

Once-through system. Light oil cooling and weak ammonia liquor waste waters treated biologically (activated sludge) for removal of phenols.

Normal gross plant effluent waste load is estimated at 306 l/kkg of coke (108 gal/ton) flow, (without dilution water), and 0.52 kg ammonia, 0.0102 kg BOD5, 0.0169kg cyanide, 0.0000288 kg phenol, 0.00113 kg oil and grease, 0.074 kg suspended solids and 0.0000117 kg sulfide per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia, BOD5, cyanide, phenol, oil and grease, suspended solids, and sulfide are 28.8%, 98.5%, 71.8%, 99.8%, 99.1%, 0%, and 99.96%, respectively.

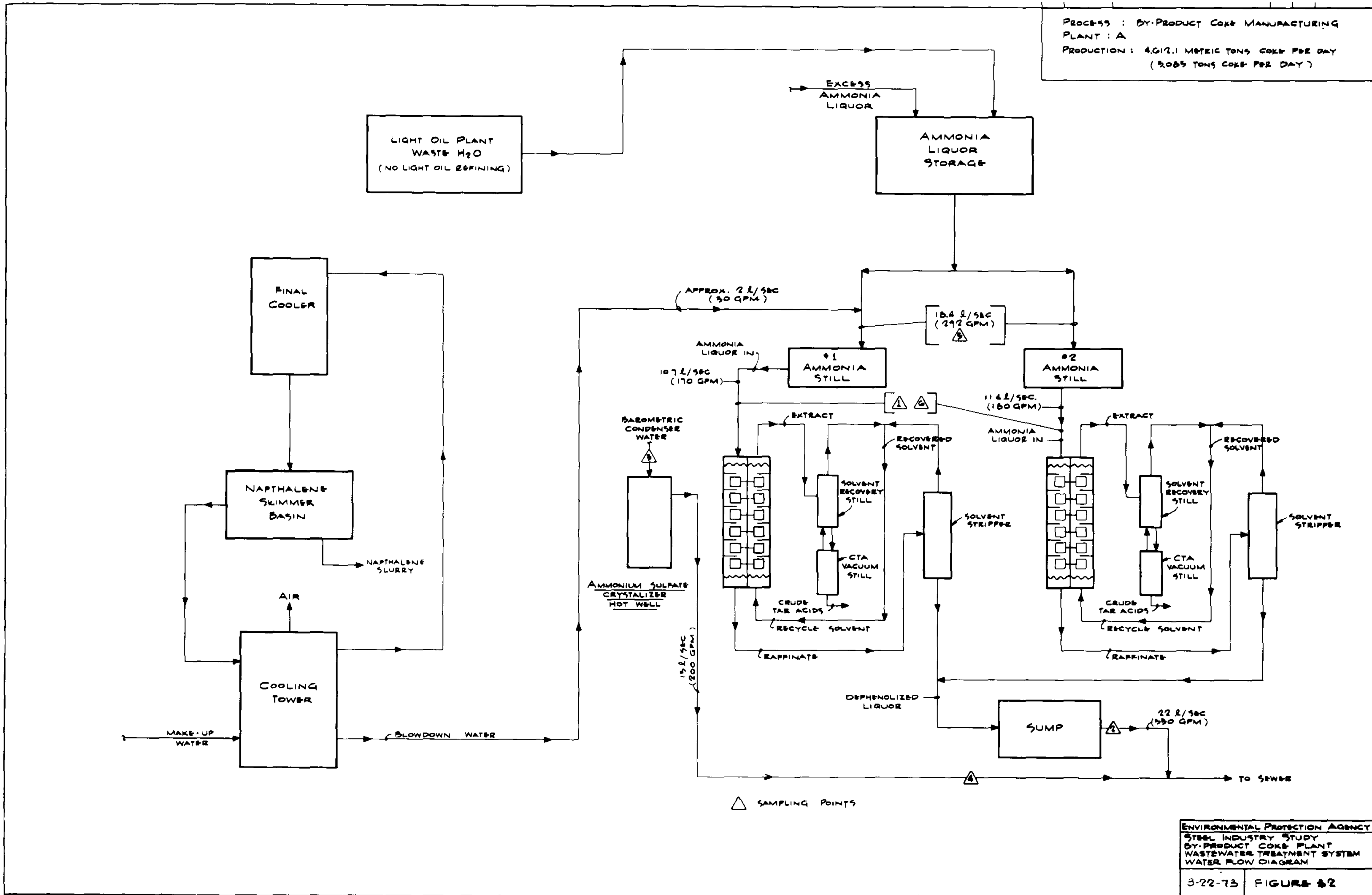
Plant C - Figure 34

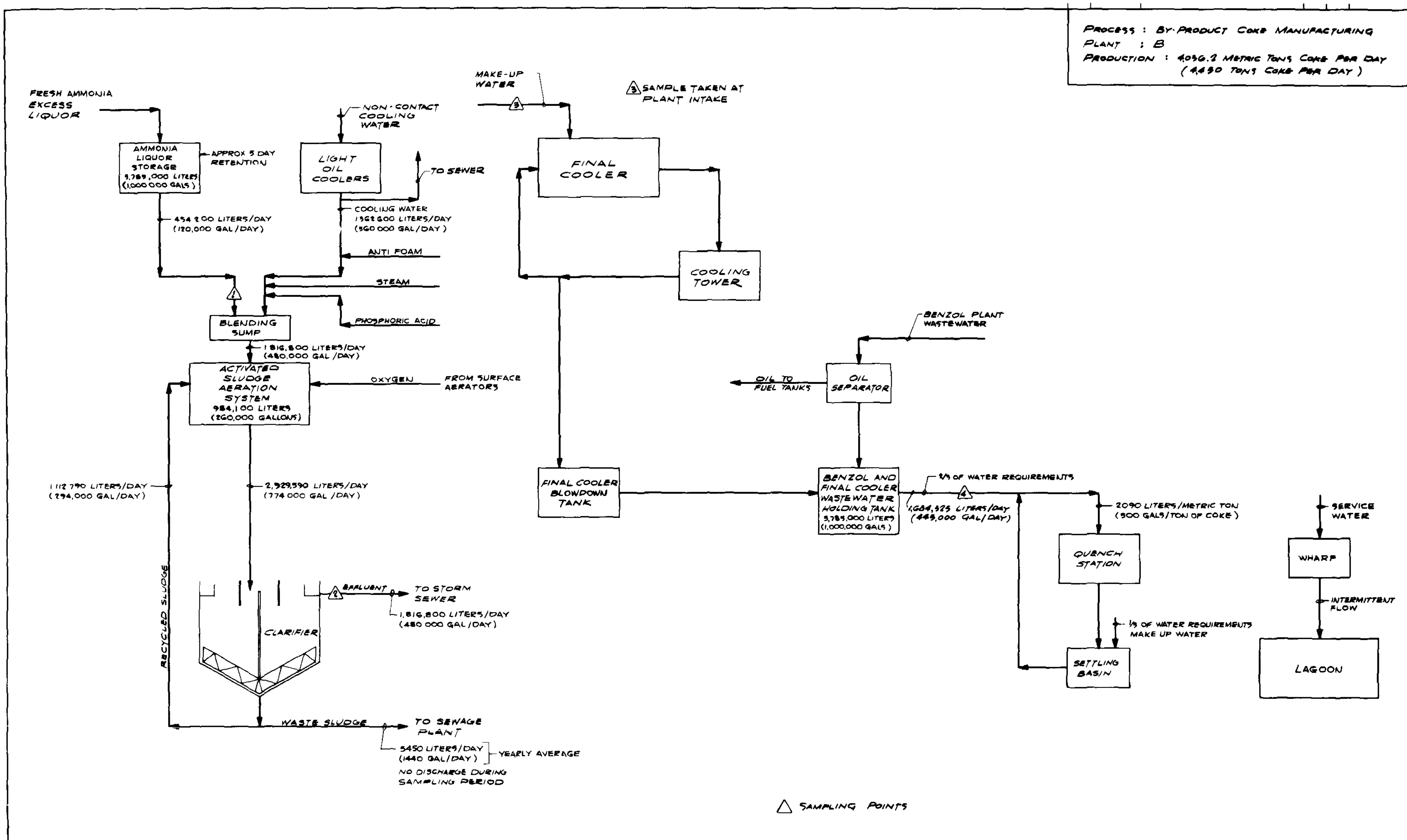
Weak ammonia liquor waste water treated in once-through system with dephenolizer followed by ammonia still operating on both free and fixed legs followed by settling basins. Light oil waste water used as make-up for coke quench station with closed recycle system. Normal gross plant effluent waste load is estimated at 174 l/kkg of coke (41 gal/ton) flow and 0.08 kg ammonia, 0.091 kg BOD5, 0.0215 kg cyanide, 0.037 kg phenol, 0.00316 kg oil and grease, 0.0174 kg suspended solids and 0.019 kg sulfide per kkg (lb/1,000 lb) of coke produced.

Overall net removals of ammonia, BOD5, cyanide, phenol, oil and grease, suspended solids, and sulfide are 92.9%, 47.7%, 18.4%, 73.4%, 80.2%, 74.4%, and 37.0%, respectively.

Plant D - Figure 35

Weak ammonia liquor waste water treated in once-through system with desulfizer tower followed by dephenolizer followed by ammonia still operating on both free and fixed legs. Non contact cooling water blended with once-through treatment effluent.

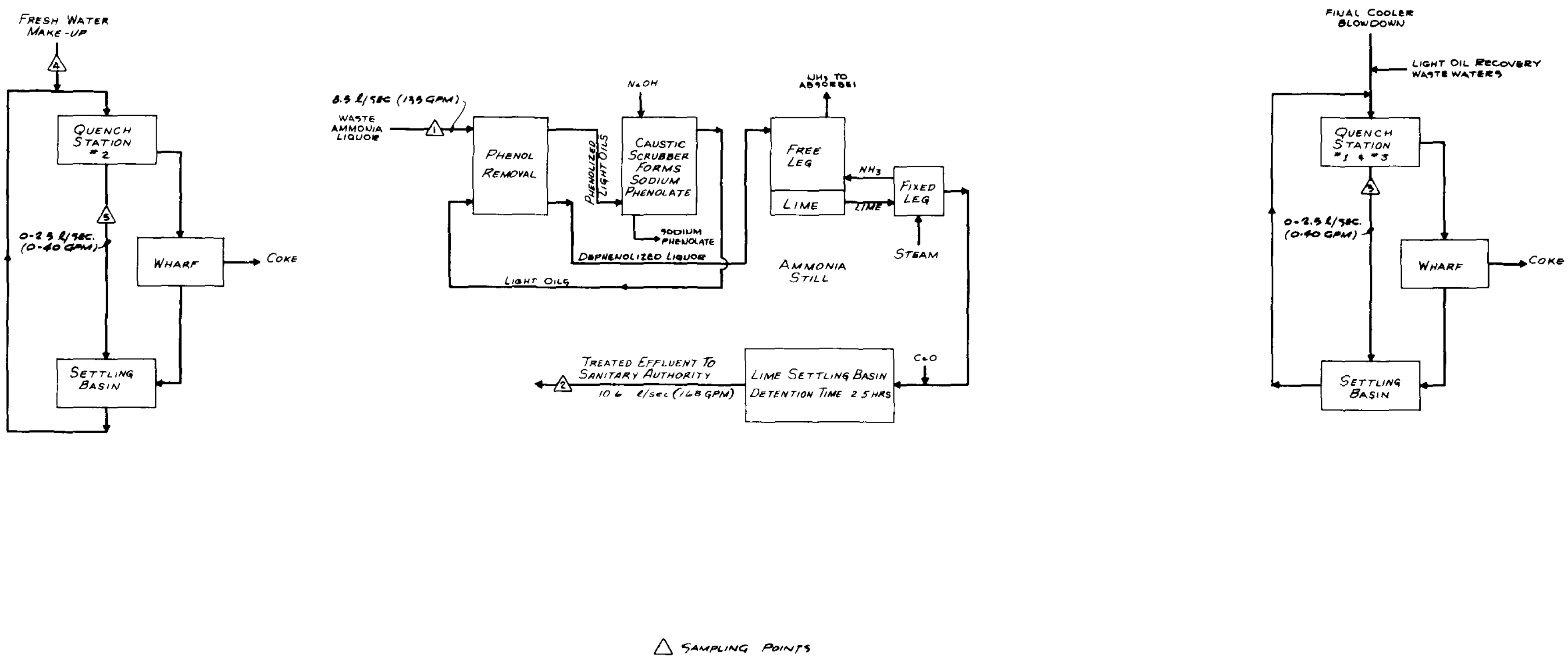

PROCESS : BY-PRODUCT COKE MANUFACTURING
PLANT : A
PRODUCTION : 4,612.1 METRIC TONS COKE PER DAY
(5,085 TONS COKE PER DAY)
LIGHT OIL PLANT WASTE H_2O (NO LIGHT OIL REFINING)
EXCESS AMMONIA LIQUOR
AMMONIA LIQUOR STORAGE
FINAL COOLER
NAPTHALENE SKIMMER BASIN
NAPTHALENE SLURRY
AIR
COOLING TOWER
MAKE-UP WATER
BLOWDOWN WATER
APPROX. 2 ℓ/SEC (30 GPM)
18.4 ℓ/SEC (292 GPM)
AMMONIA LIQUOR IN
10.7 ℓ/SEC (170 GPM)
#1 AMMONIA STILL
#2 AMMONIA STILL
11.4 ℓ/SEC. (180 GPM)
AMMONIA LIQUOR IN
BAROMETRIC CONDENSER WATER
AMMONIUM SULFATE CRYSTALIZER HOT WELL
12 ℓ/SEC (200 GPM)
EXTRACT
RECOVERED SOLVENT
SOLVENT RECOVERY STILL
CTA VACUUM STILL
CRUDE TAR ACIDS
RECYCLE SOLVENT
RAFFINATE
SOLVENT STRIPPER
DEPHENOLIZED LIQUOR
SUMP
22 ℓ/SEC (350 GPM)
TO SEWER
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
3-22-73
FIGURE 12



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

3-22-73 FIGURE 33

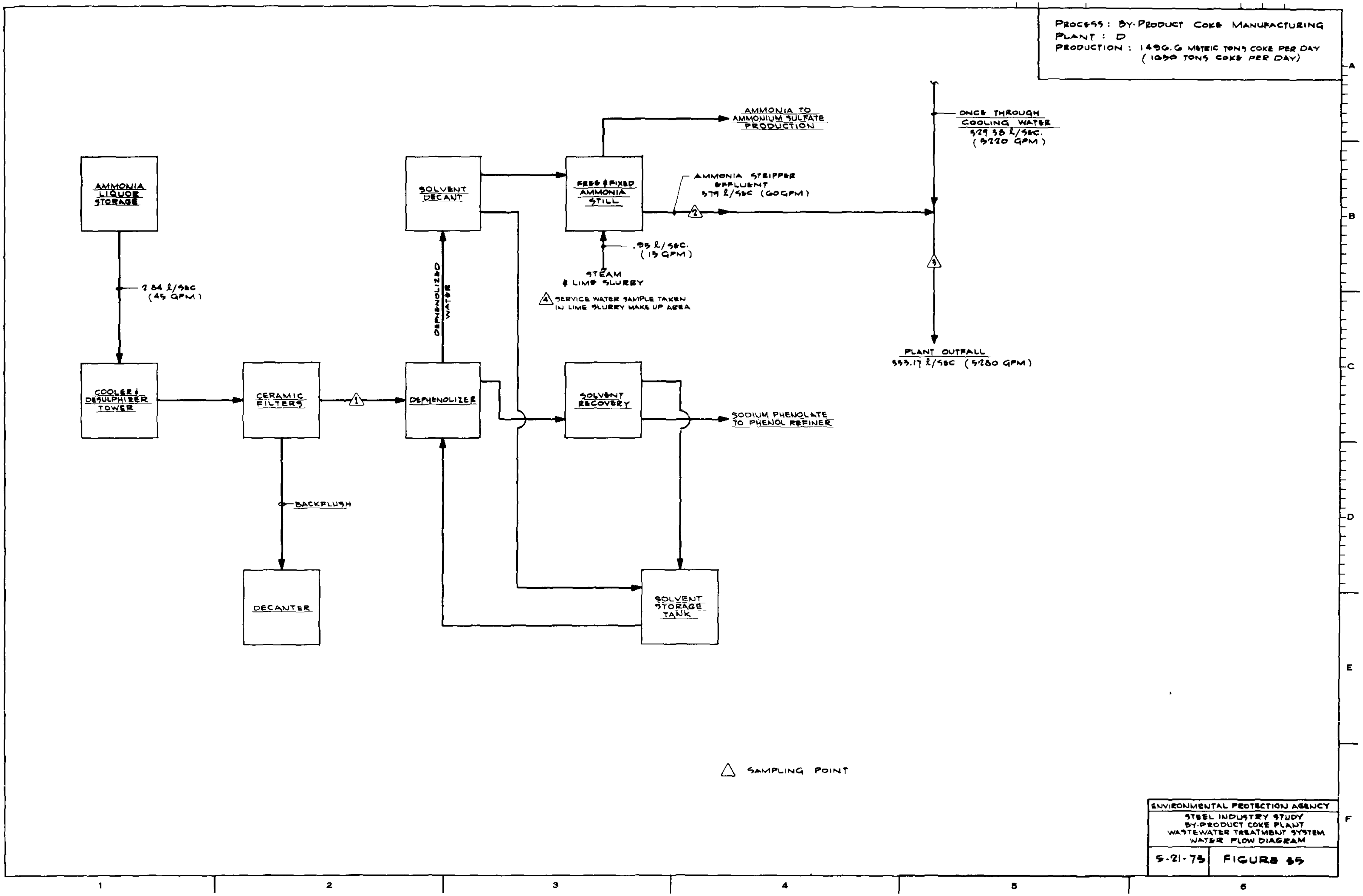
PROCESS : BY-PRODUCT COKE MANUFACTURING
PLANT-C
PRODUCTION 5399.4 METRIC TONS COKE PER DAY (5,959 TONS COKE PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY PRODUCT COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-7-73

FIGURE 34


PROCESS: BY-PRODUCT COKE MANUFACTURING
PLANT: D
PRODUCTION: 1496.6 METRIC TONS COKE PER DAY
(1650 TONS COKE PER DAY)
AMMONIA LIQUOR STORAGE
2.84 ℓ/SEC (45 GPM)
COOLER & DESULPHIZER TOWER
CERAMIC FILTERS
BACKFLUSH
DECANTER
DEPHENOLIZER
DEPHENOLIZED WATER
SOLVENT DECANT
FREE & FIXED AMMONIA STILL
AMMONIA TO AMMONIUM SULFATE PRODUCTION
AMMONIA STRIPPER EFFLUENT 3.79 ℓ/SEC (60 GPM)
.95 ℓ/SEC. (15 GPM)
STEAM & LIME SLURRY
SERVICE WATER SAMPLE TAKEN IN LIME SLURRY MAKE UP AREA
SOLVENT RECOVERY
SODIUM PHENOLATE TO PHENOL REFINER
SOLVENT STORAGE TANK
ONCE THROUGH COOLING WATER 329.38 ℓ/SEC. (5220 GPM)
PLANT OUTFALL 333.17 ℓ/SEC (5280 GPM)
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-21-75
FIGURE 35

Normal gross plant effluent waste load is estimated at 19,400 l/kkg of coke (4,600 gal/ton) flow, (contains contaminated once-through cooling water), and 0.035 kg ammonia, 0.096 kg BOD5, 0.156 kg cyanide, 0.0010 kg phenol, 0.00038 kg oil and grease, 0.135 kg suspended solids, and 0.0288 kg sulfide per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia, BOD5, cyanide, phenol, oil and grease, suspended solids, and sulfide are 95.3%, 61.2%, 0%, 99.1%, 99.5%, 76.6%, and 64.4%, respectively.

Beehive Coke Subcategory

Wastewater treatment at beehive operations ranges from once through water flow with no treatment provisions, once through systems with settling basins to collect minute fines, and a complete recycle of water to quench.

Plant Visits

Three beehive coke plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 35 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

Plant E - Figure 36

Coke quench waste water treated by once through system composed of simple settling ponds.

Normal gross plant effluent waste load is estimated at 2,070 l/kkg of coke (490 gal/ton) flow, and 0.00049 kg ammonia, 0.00202 kg BOD5, 0.0000081 kg cyanide, and 0.0000286 kg phenol per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia BOD5, cyanide, and phenol are 39.7%, 80%, 20.1%, and 12.6%, respectively.

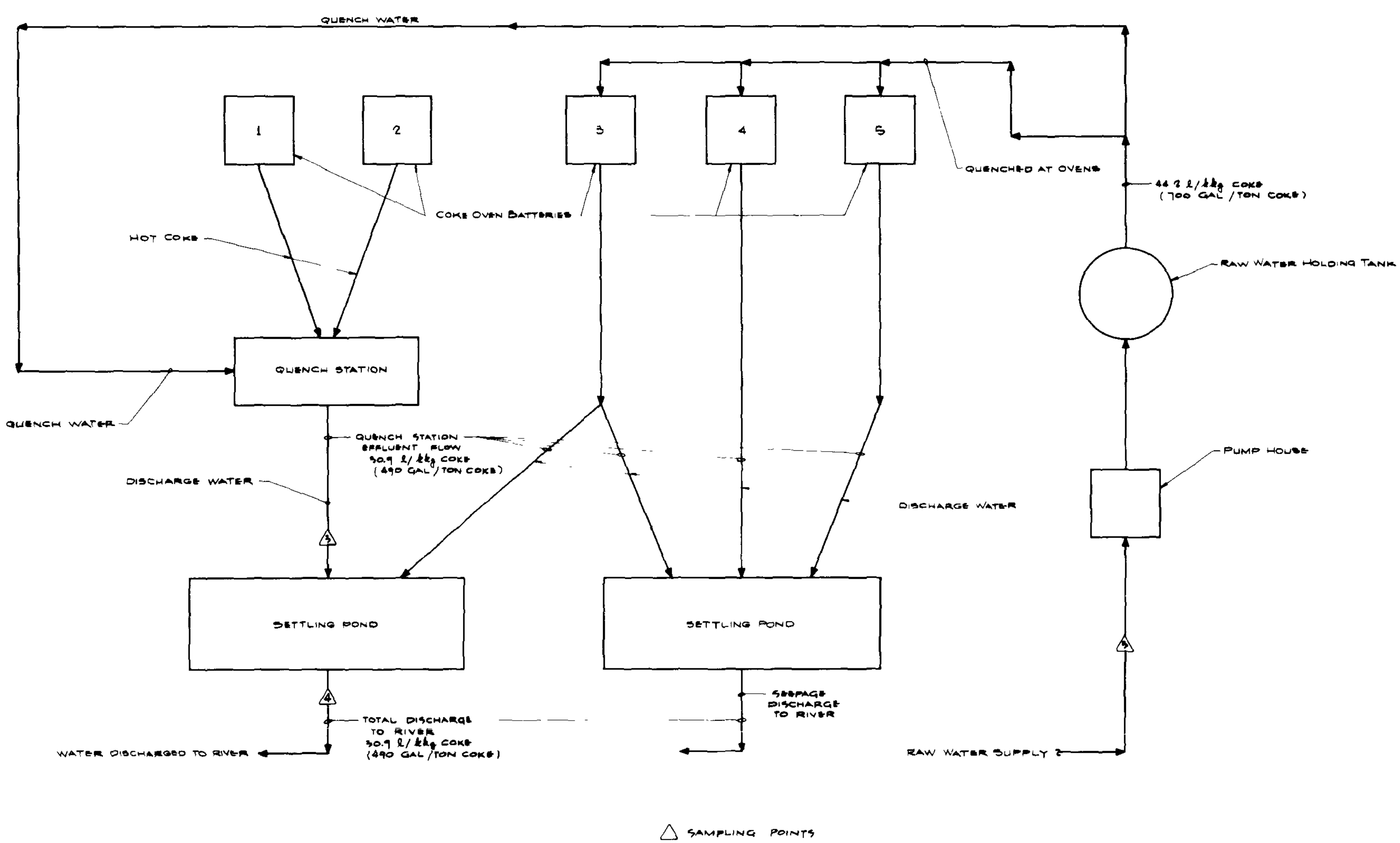
Plant F - Figure 37

Coke quench waste water recirculated and reused. No effluent waste water. Make-up as required.

Normal gross effluent waste load is zero since there is no discharge.

Plant G - Figure 38 Coke quench waste water recirculated and reused. No effluent discharge. Make-up as required.

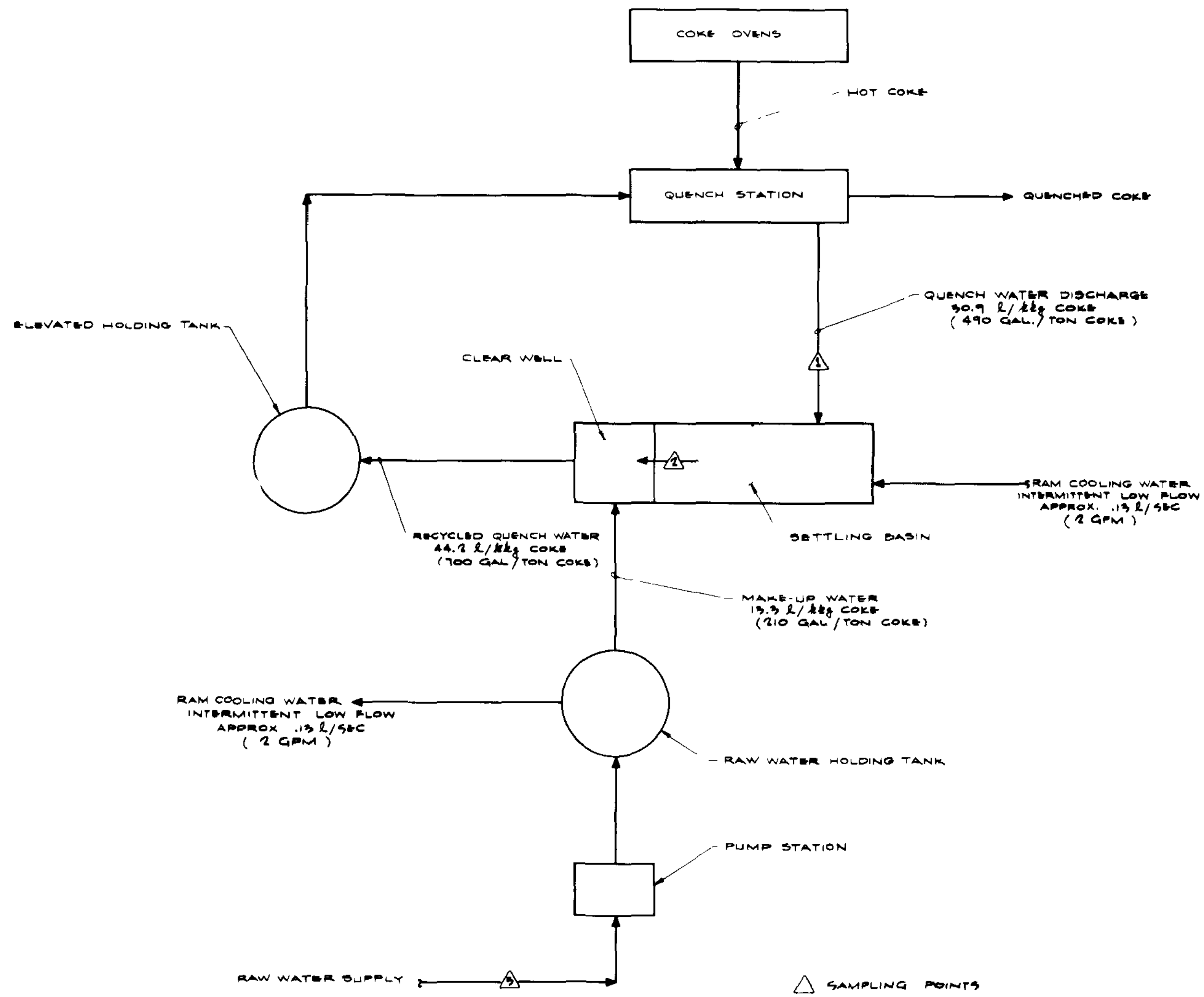
Normal gross effluent waste load is zero since there is no discharge.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEE HIVE COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

3-23-73 FIGURE 36

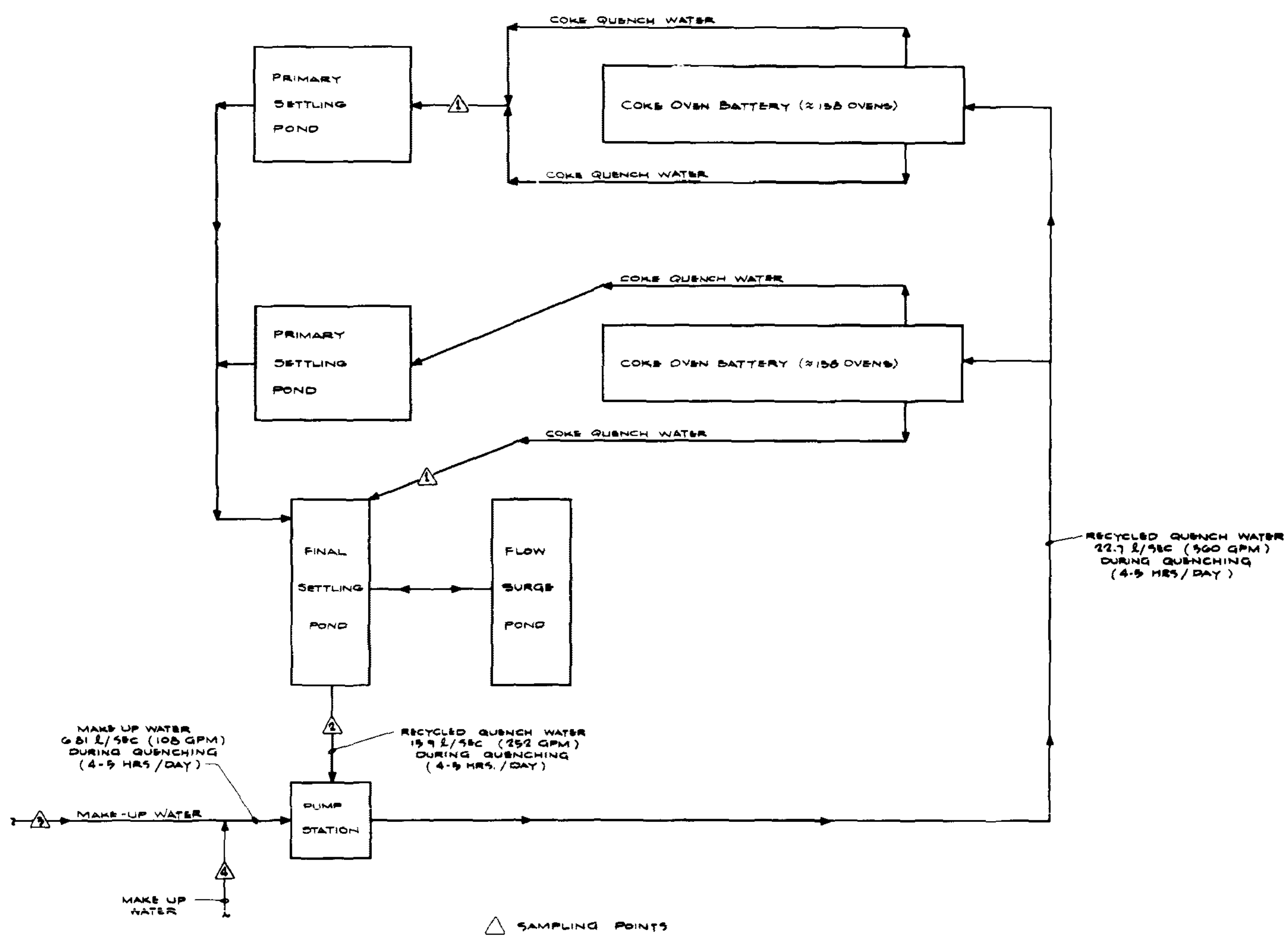
Process : Bee Hive Coke Manufacturing
Plant : F
Production : 907 Metric Tons Coke per Day
(1000 Tons Coke per Day)



Environmental Protection Agency
Steel Industry Study
Bee Hive Coke Plant
Wastewater Treatment System
Water Flow Diagram

3-22-73 | FIGURE 37

PROCESS : BEE HIVE COKE MANUFACTURING
PLANT : G
PRODUCTION : 558.7 METRIC TONS COKE PER DAY
(616 TONS COKE PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEE HIVE COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-24-73 FIGURE 38

Sintering Subcategory

Treatment of sinter plant aqueous wastes primarily centers on two basic systems dependent on the scrubbing system employed.

When scrubbers are used for the dedusting systems, the scrubber aqueous discharges are either "once through" or "recycled" through a thickener. The thickener underflow is decanted with centrifuges or vacuum filters with the filtrates being returned to the thickeners and the filter cake being returned to the sinter plant.

When high energy venturi scrubbers are used in place of precipitators for the sinter bed exhaust system, the scrubber aqueous discharges are treated in the same manner as the dedusting system, but may require magnetic or chemical flocculation to increase the settling efficiencies.

Plant Visits

Four sintering plants were visited during the survey. However, the data are not as complete as with other subcategories of the project. This is due to several reasons, namely:

a. Tie in with other plant processes, such as the blast furnace. This poses a problem in determining the effectiveness of the treatment facility on the sinter plant portion of the waste waters.

b. The effluent of one plant was not sampled due to the malfunctioning of a portion of the treatment equipment.

c. Failure of one plant to provide information relative to costs and daily production. Sampling was performed but the data could not be correlated.

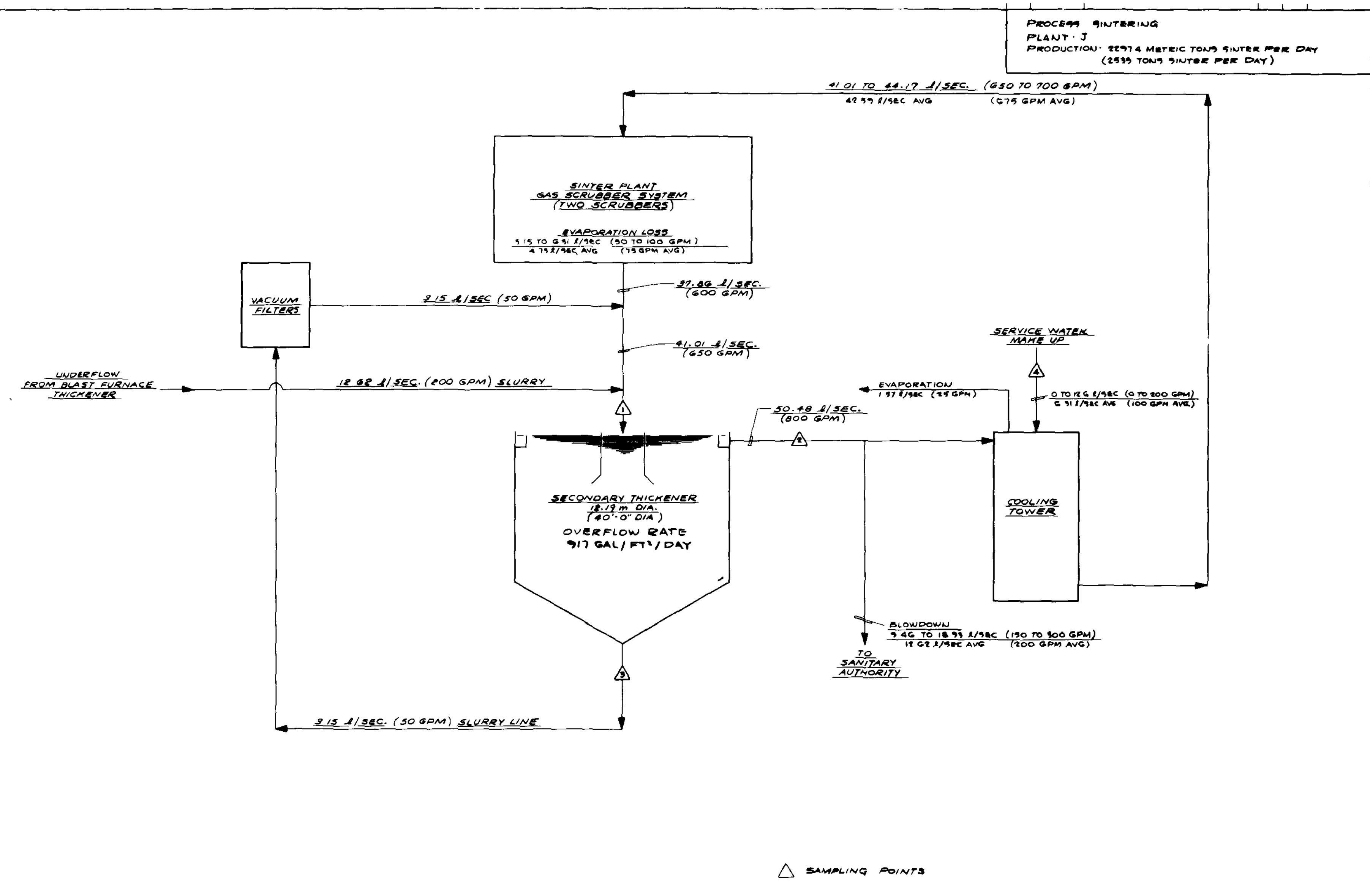
Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 36 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and individual wastewater treatment systems are presented.

Plant H - Figure 39

Sinter plant scrubber waste waters are combined with blast furnace and other steel making waste waters and treated via chemical coagulation and thickening followed by discharge to the receiving stream.

No effluent sample was obtained due to a malfunction of the chemical treatment system.

Plant J - Figure 40



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-15-73 FIGURE 39

Gas scrubber water on a tight recycle system. Loop contains gas scrubbers, thickener and cooling tower.

Normal gross plant effluent waste load is estimated at 486 l/kkg of sinter (114 gal/ton) flow, and 0.000474 kg oil and grease, 0.00427 kg suspended solids, 0.00403 kg fluoride, and 0.00511 kg sulfide per kkg (lb/1,000 lb) of sinter produced.

Overall removals for oil and grease and suspended solids are approximately 100% and for sulfides are 94.5%.

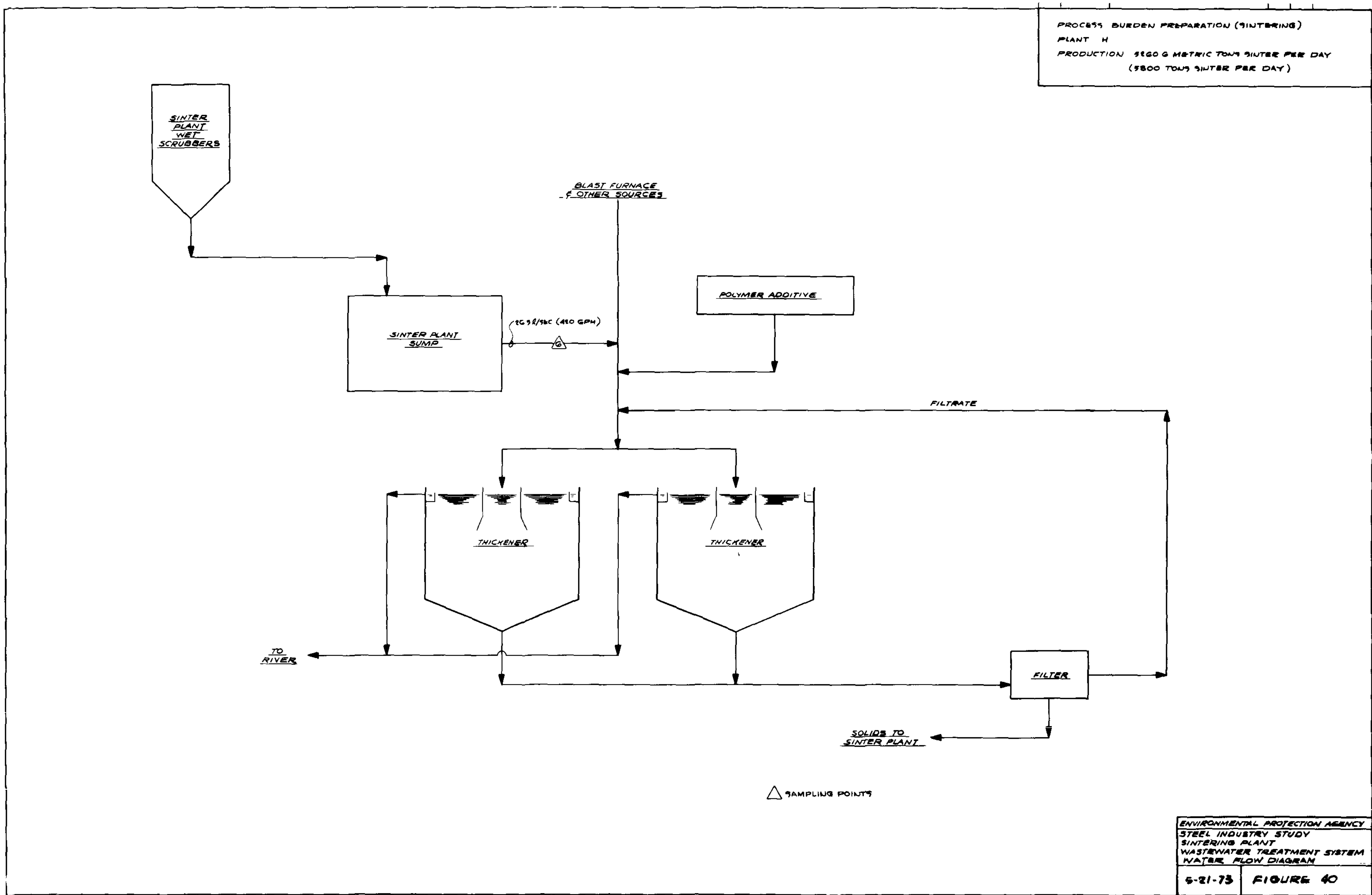
Blast Furnace Operations

Several different treatment systems have been used throughout the years to treat the waste water from blast furnace gas cleaning systems. Some of these have been fairly successful; however, others are experimental in nature and have yet to be resolved. They are listed here according to the degree of treatment they provide. The basic treatment system was designed for the removal of particulate matter and not for the removal of the chemicals in the waste waters. The ultimate treatment system is the one that not only removes the solids but also the chemical from the waste.

a. The simplest system for treating blast furnace gas wash water has been a rectangular settling tank. Here the solids were allowed to settle and the clarified overflow water discharged to the receiving stream. The settled material is removed from an idle unit by a clam shell bucket and trucked to landfill while material settles out in a second unit. This is the simplest type of settling tank; however, the handling of the wet sludge created many problems. These have been replaced by more sophisticated equipment which pumps the settled sludge to vacuum filters for further dewatering.

b. The rectangular settling tank has been replaced with a circular thickener or clarifier. The dirty water from the gas scrubber enters in the center, the solids settle to the bottom, and the clarified water overflows around the circumference of the tank. The sludge is pumped from the bottom of the thickener to vacuum filters where the solids are filtered from the water and the filtrate returned to the thickener. The overflow water from the thickener is discharged to the receiving stream as most of the solids have been removed. Most all blast furnaces are equipped with this type of system for the removal of suspended solids in the wash water. This system, however, does not appreciably affect the chemical composition of the water.

c. A few plants have modified the above system to discharge the clarified overflow from the thickener back into the water intake for the total plant water system. Here the water is diluted with incoming fresh water and used throughout the various noncontact


PROCESS BURDEN PREPARATION (SINTERING)
PLANT H
PRODUCTION 5260 G METRIC TONS SINTER PER DAY
(5800 TONS SINTER PER DAY)
SINTER PLANT WET SCRUBBERS
SINTER PLANT SUMP
26.5 l/SEC (420 GPM)
G
BLAST FURNACE & OTHER SOURCES
POLYMER ADDITIVE
FILTRATE
THICKENER
THICKENER
TO RIVER
FILTER
SOLIDS TO SINTER PLANT
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-21-73
FIGURE 40

cooling systems within the plant as well as for make-up water to the blast furnace gas cleaning system. In these plants, the noncontact cooling water is discharged at a point not near the plant intake. Returning the clarified water from the thickener to the plant intake dilutes the water and treats it by aeration in cooling towers, etc., in a noncontact cooling system of the plant. It is then discharged in an area where it cannot be picked up by the water intake pumps. This system makes no attempt to treat the chemical wastes other than by dilution and aeration throughout the noncontact cooling system.

d. At least one plant is taking the thickener overflow from a once through system and passing it through a continuous alkaline chlorination system for the total destruction of cyanide and phenols. The effluent from the alkaline chlorination treatment system goes to a clarifier and sand filter prior to being returned to the plant intake water system for recycle through the plant. This treated effluent shows virtually complete elimination of suspended solids, cyanide, phenol, and sulfide. Ammonia concentrations are also reduced by 70 percent, and the treated waters that are recycled to the plant intake are normally of higher quality than the raw river water used as make-up. The blend of treated and raw water is not only used as process water in the sinter plant and blast furnace gas washer system, but also as process water for merchant mills and blooming mills in other areas of the manufacturing complex.

e. Recycle systems are also in use in some plants. The thickener overflow is collected in a tank and returned to the gas cleaning system without the benefit of a cooling tower to cool the water. This system takes advantage of the surface cooling effect of the thickener; however, it operates at a higher recirculation water temperature than in other systems. The blowdown from this recycle system is discharged to the local stream. The sludge is pumped to a vacuum filter for further dewatering and recovery. There are only a few plants operating with this type system.

f. The basic recycle system in use today uses a thickener to remove the solids from the blast furnace gas wash water. The thickener overflow goes into a tank and is pumped to a cooling tower where the water is cooled and returned to the gas washer for reuse. The system is also equipped with a vacuum filter to dewater the sludge and the filtrate is returned to the thickener. The effluent from the system is the blowdown from the cooling tower which is free of settleable solids. This is discharged to the local streams. No effort is made to treat the chemical composition of the wash water, however, the aeration in the cooling tower tends to oxidize and reduce the chemical composition of these waters.

g. At least one steel company is using a bio-oxidation system for the destruction of cyanide. Information available on this system is limited; however, the large volumes of water requiring treatment and the sensitivity of bio-oxidation systems requires careful attention to details of operation.

h. At least one blast furnace is operating a wash water recycle system without a discharge to the receiving stream by discharging the blowdown to the local sanitary authority for treatment in the sewage treatment plant. This appears to be working out satisfactorily. There is a question, however, whether the sewage treatment plant is effectively treating the chemical blowdown, or diluting the waste to where it cannot be found. Few sewage treatment systems are designed to handle this increased hydraulic loading. Any municipal treatment system receiving the blowdown from a blast furnace gas wash water system is likely to impose strict limitations on the volume and composition of water that it can handle. Problems therefore develop during periods of upset and equipment cleaning on how to handle the extra waste water. Overloading the municipal treatment system could cause undue problems for the municipality.

i. Another route to the disposal of the waste water from a blast furnace gas wash water system is a complete recycle system with thickeners, cooling towers, and vacuum filters with precise control over the blowdown from the system. The blowdown is totally evaporated by slag and coke quenching and in the BOF hood cooling. Several plants are doing this; however, not all blast furnaces have the advantage of readily available coke quenching and BOF hood cooling operations convenient to their site. This system therefore may not apply to all blast furnaces. In addition, trace amounts of chemicals are released into the atmosphere to become an air pollution problem. The extent of this air pollution problem has not been established.

j. Blowdowns from recycle systems may be handled in ways other than by discharge to receiving streams. Incineration of the blowdown is one method of accomplishing this. This would be practical only if surplus blast process gas fuel were available to operate the incinerator. It would, however, oxidize or destroy the chemical components of the waste. If the total evaporation of slag and coke quenching is a satisfactory method for eliminating the dissolved solids from recycle system, then evaporation using available waste heat from the blast furnace could also be used.

A zero discharge from the gas wash water system could be accomplished by demineralizing the blowdown and returning the condensate to the system as demineralized makeup water. The concentrated brine could be disposed of as a concentrated brine, it could be taken to complete dryness, or it could be further concentrated and the solids crystallized out and removed by filters and disposed of in landfill. Incineration, demineralization, and evaporation by waste heat recovery have not been tried. However, these are ways of eliminating the blowdowns from these systems and should be investigated.

k. There is presently being designed a recycle system for the blast furnace gas wash water system that will have no blowdown other than the moisture in the filter cake that leaves the system via the vacuum filters. Preliminary tests and calculations have indicated that such a system is possible. If this system is made to work, it would be the ultimate way of operating a blast furnace recycle system with no blowdown. However, this system would not be applicable to all blast furnaces.

l. The ultimate disposal of blast furnace gas wash water is the operation of a system with no blowdown to the receiving stream. Several plants are operating in this manner, however, no one can be applied to all mills.

Plant Visits

Five iron making blast furnaces and one ferro-manganese blast furnace were visited during the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Tables 37 and 38 present a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

Plant L - Figure 41

Gas cleaning water on loose recirculation system with maximum blowdown. Loop includes gas scrubber, thickener, alkaline chlorination unit, and sand filter.

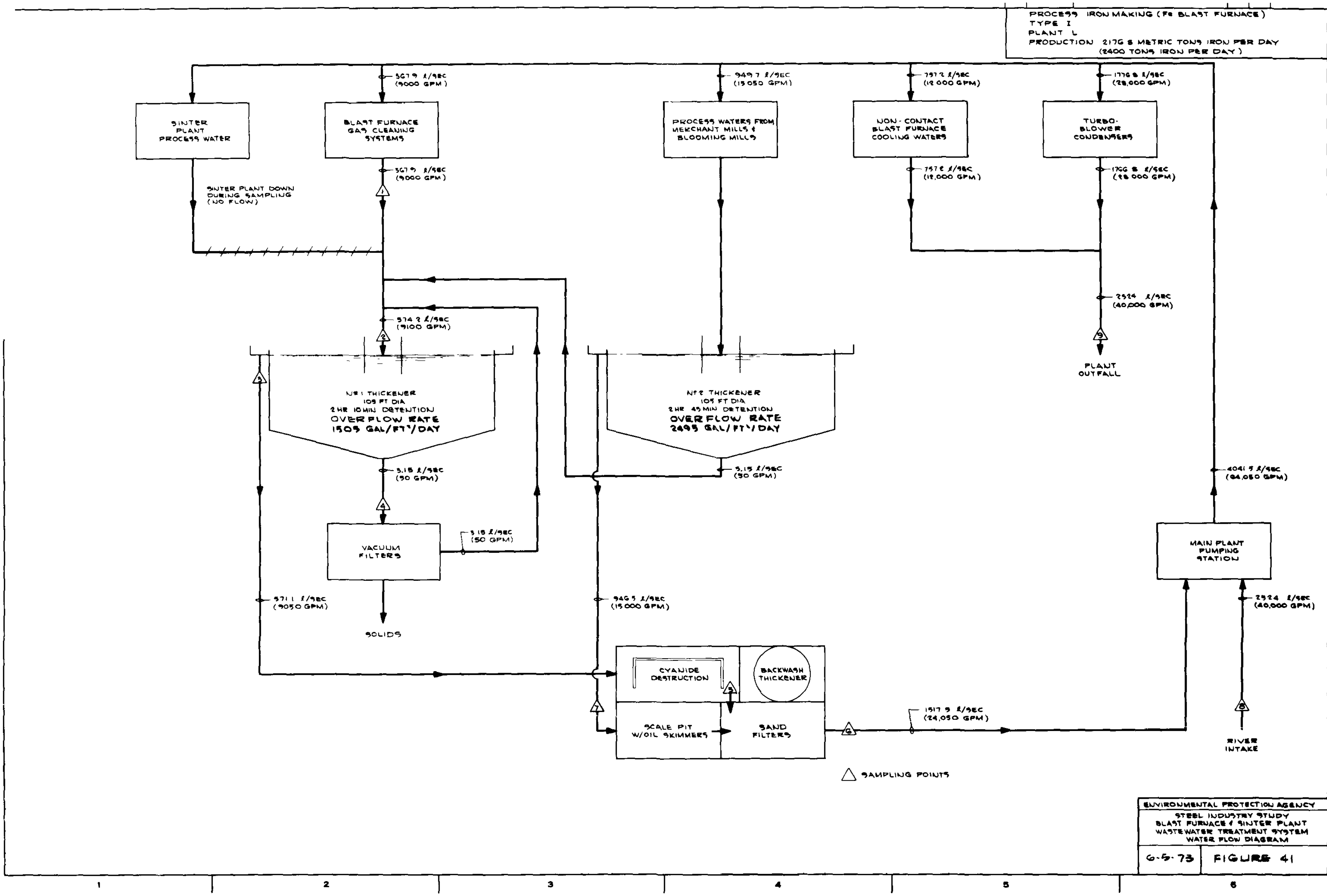
Normal gross plant effluent waste load is estimated at 23,000 l/kkg of iron (5,400 gal/ton) flow, and 0.084 kg ammonia, 0.0005 kg cyanide, 0.0014 kg phenol, 1.1 kg suspended solids, and 0.0043 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 24.9%, 98.5%, 90.1%, 97.3%, and 96.1%, respectively.

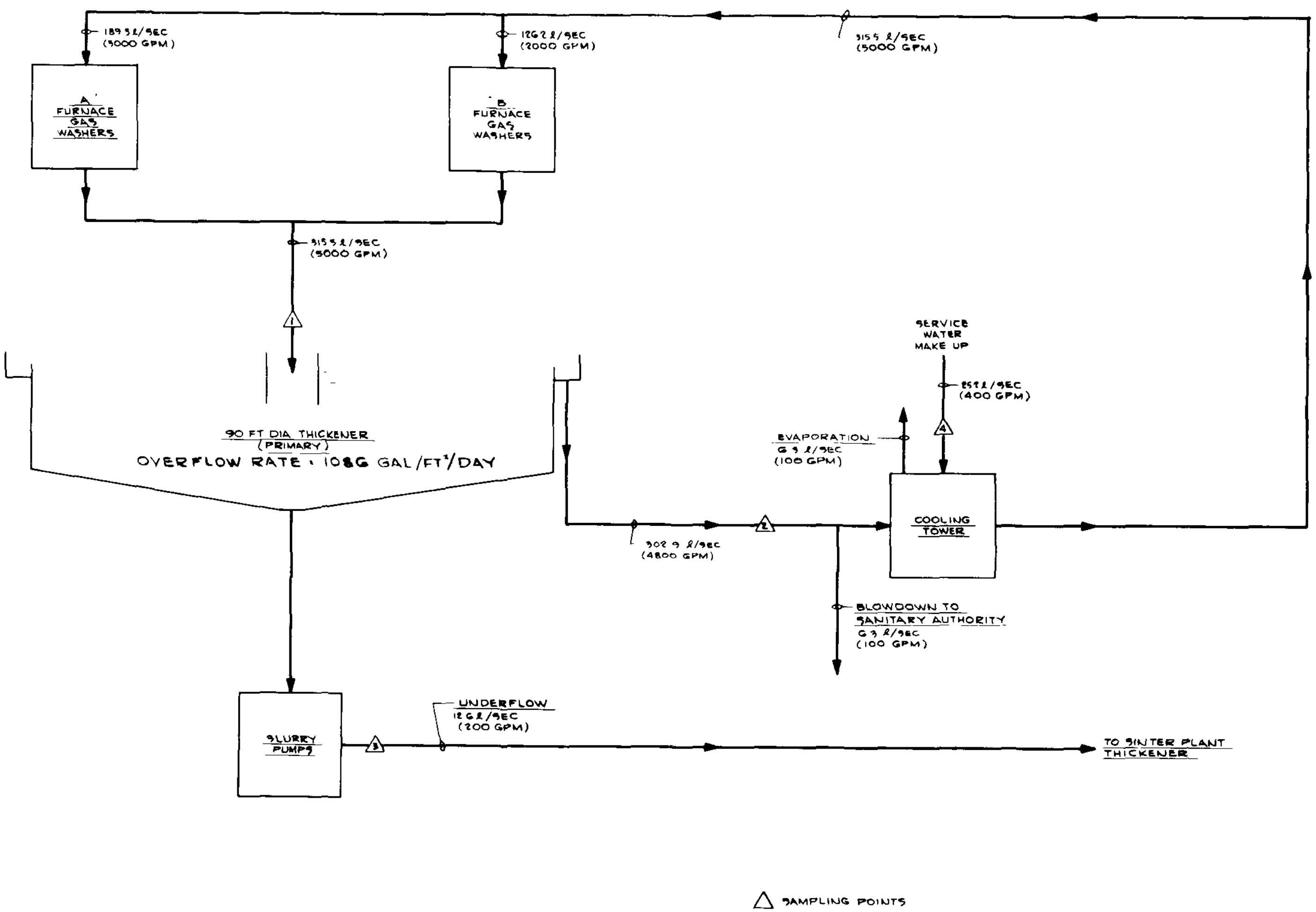
Plant M - Figure 42

Gas cleaning water on tight recycle system with minimal blowdown. Loop includes scrubbers, thickener and cooling tower.

Normal gross plant effluent load is estimated at 525 l/kkg of iron (123 gal/ton) flow, and 0.044 kg ammonia, 0.0087 kg cyanide, 0.0184 kg phenol, 0.0436 kg suspended solids, and 0.00249 kg sulfide per kkg (lb/1,000 lb) of iron produced.


PROCESS IRON MAKING (Fe BLAST FURNACE)
TYPE I
PLANT L
PRODUCTION 2176.8 METRIC TONS IRON PER DAY
(2400 TONS IRON PER DAY)
SINTER PLANT PROCESS WATER
BLAST FURNACE GAS CLEANING SYSTEMS
PROCESS WATERS FROM MERCHANT MILLS & BLOOMING MILLS
NON-CONTACT BLAST FURNACE COOLING WATERS
TURBO-BLOWER CONDENSERS
567.9 ℓ/SEC (9000 GPM)
949.7 ℓ/SEC (15 050 GPM)
757.2 ℓ/SEC (12 000 GPM)
1766.8 ℓ/SEC (28,000 GPM)
SINTER PLANT DOWN DURING SAMPLING (NO FLOW)
2524 ℓ/SEC (40,000 GPM)
PLANT OUTFALL
574.2 ℓ/SEC (9100 GPM)
Nº1 THICKENER
105 FT DIA
2 HR 10 MIN DETENTION
OVERFLOW RATE
1505 GAL/FT²/DAY
Nº2 THICKENER
105 FT DIA
2 HR 45 MIN DETENTION
OVERFLOW RATE
2495 GAL/FT²/DAY
3.15 ℓ/SEC (50 GPM)
VACUUM FILTERS
SOLIDS
571.1 ℓ/SEC (9050 GPM)
946.5 ℓ/SEC (15 000 GPM)
4041.5 ℓ/SEC (64,050 GPM)
MAIN PLANT PUMPING STATION
CYANIDE DESTRUCTION
BACKWASH THICKENER
SCALE PIT W/OIL SKIMMERS
SAND FILTERS
1517.5 ℓ/SEC (24,050 GPM)
RIVER INTAKE
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE & SINTER PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
6-5-73
FIGURE 41

PROCESS IRON MAKING (Fe BLAST FURNACE)
TYPE II
PLANT M
PRODUCTION 3174.5 METRIC TONS IRON PER DAY
(3500 TONS IRON PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-24-73 FIGURE 42

Overall removals for ammonia, cyanide, phenol, suspended solids, and sulfide are 0%, 0%, 0%, 99.2%, and 0%, respectively.

Plant N - Figure 43

Gas cleaning water on tight recycle system with minimal blowdown. Loop includes scrubbers, thickener, and cooling tower.

Normal gross effluent waste load is estimated at 428 l/kkg of iron (gal/ton) flow, and 0.112 kg ammonia, 0.0078 kg cyanide, 0.0000144 kg phenol, 0.0164 kg suspended solids, and 0.00175 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals for ammonia, cyanide, phenol, suspended solids, and sulfide are 20.1%, 0.0%, 99.8%, 99.6%, and 0.0%, respectively.

Plant O - Figure 44

Gas cooling and cleaning water on tight recycle system with minimal blowdown. Loop includes gas coolers and scrubbers, thickeners, and cooling towers.

Normal gross plant effluent waste load is estimated at 440 l/kkg of iron (104 gal/ton) flow, and 0.0434 kg ammonia, 0.00469 kg cyanide, 0.0000044 kg phenol, 0.0199 kg suspended solids, and 0.00299 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 73.0%, 0.0%, 99.6%, 99.9%, and 0.0%, respectively.

Plant Q - Figure 45

Once-through gas cooling system. Gas cleaning water on closed recycle loop. Loop includes gas scrubber and thickener.

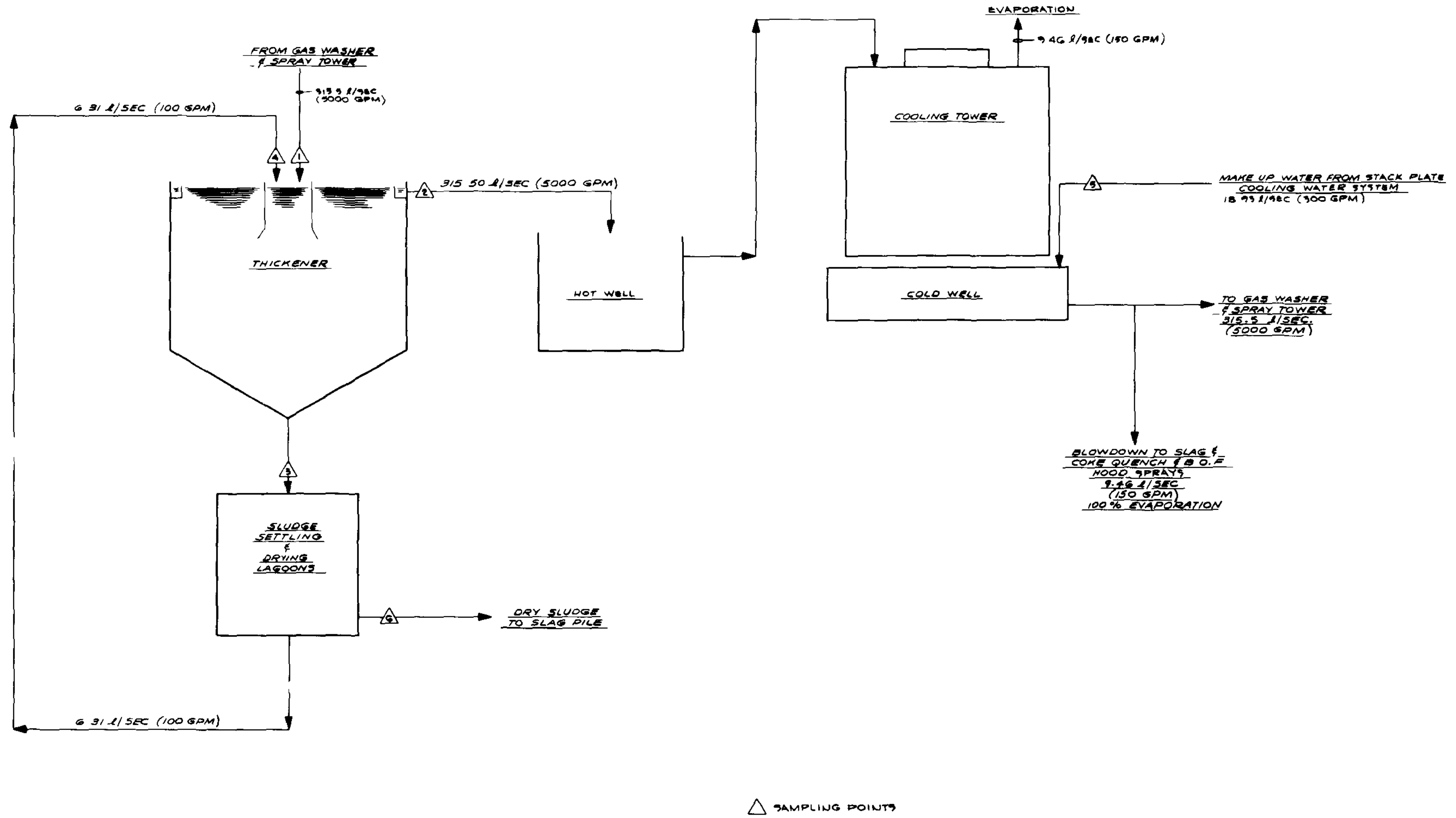
Normal gross effluent waste load is estimated at 24,000 l/kkg of ferromanganese (5,700 gal/ton) flow, and 3.92 kg ammonia, 2.54 kg cyanide, 0.144 kg manganese, 0.011 kg phenol, 1.78 kg suspended solids, and 2.42 kg sulfide per kkg (lb/1,000 lb) of ferromanganese produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 0%, 0%, 0%, 99.2%, and 0% respectively.

Basic Oxygen Furnace Operation

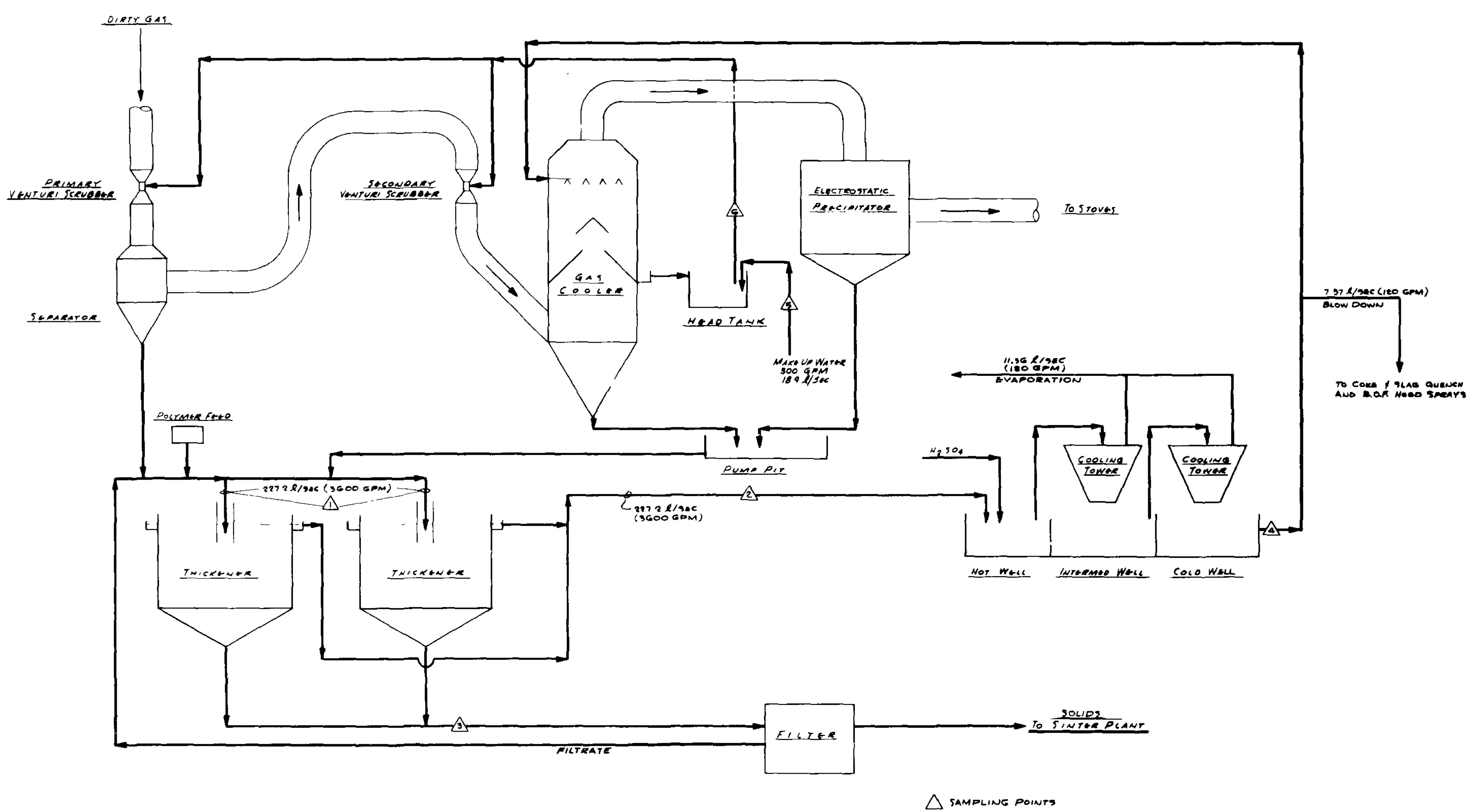
The waste water produced is primarily the result of the fume collection system employed. There is no discharge on the dry type precipitator system and hence no waste water treatment is involved.

PROCESS IRON MAKING (Fe BLAST FURNACE)
TYPE I
PLANT N
PRODUCTION 1949.1 METRIC TONS IRON PER DAY (2149 TONS IRON PER DAY)



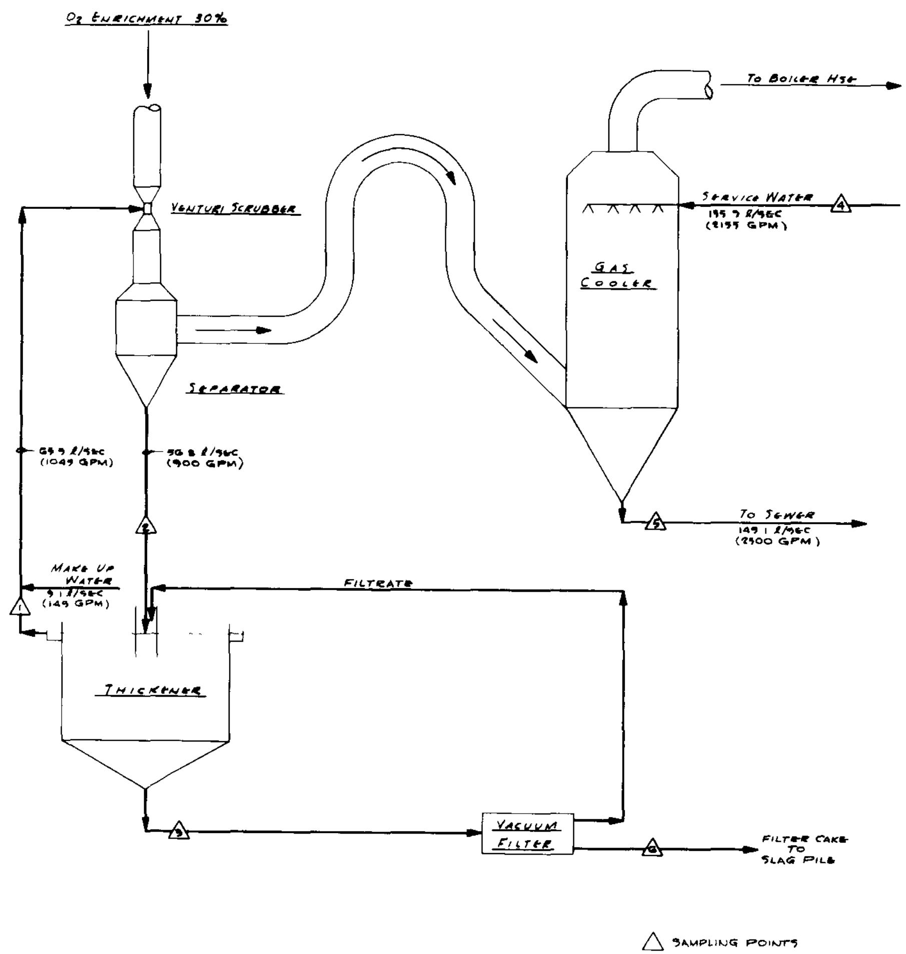
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-25-73
FIGURE 43

PROCESS IRON MAKING (Fe BLAST FURNACES)
TYPE II
PLANT: O
PRODUCTION 1505.6 METRIC TONS IRON PER DAY
(1660 TONS IRON PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
6-2-73
FIGURE 44

PROCESS IRON MAKING (FeMn BLAST FURNACE)
TYPE IV
PLANT Q
PRODUCTION 526.9 METRIC TONS FERROMANGANESE PER DAY
(581 TONS FERROMANGANESE PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-7-73 FIGURE 45

The semi-wet system employs a precipitator and gas conditioning in a spark box spray chamber. The spark box spray system utilizes an excessive spray water system.

The basic type of water control treatment system applied to this aqueous discharge is generally a steel or concrete rectangular settling tank containing a motorized flight conveyor for removing the settled solids. The water is allowed to settle some solids and then overflowed to the plant sewers while the flight conveyor removes the settled solids for truck disposal. Approximately 22-30% of the dust load ejected from the furnaces is precipitated out in the spark box chamber and discharged to the settling tank. These systems can be upgraded by magnetic and chemical flocculation systems, thus precipitating more of the submicron iron oxide fines.

These systems can be arranged for a zero aqueous discharge by adding make-up water and recycling the water back into the spark box spray system.

An alternate system to the spark-box spray or dry evaporation chamber system is to install a wetted wall type evaporation chamber. A wetted wall evaporation chamber contains no refractory lining, but uses a water wetted steel surface as the heat resistant medium. These chambers require large quantities of water to insure that the steel surfaces do not become overheated. The aqueous discharges from these systems are generally discharged to a settling chamber, make-up water is added, with chemical treatment and the water is recycled back to the evaporation chamber system. These systems employ the same water treatment techniques as the spark box discharges except the precipitated dust load is somewhat less (10%) as these systems are a cross between the spark box and dry evaporation chambers.

The wet high energy venturi scrubber fume collection systems generally use steam generating type hoods close coupled with a low energy fixed orifice quencher. As the hot gases exit from the hood, the gases are immediately quenched from 150°C to 85°C saturation temperature.

The aqueous discharge from the scrubber fume collection system is from the primary quencher with the effluent being discharged to thickeners. Most systems have thickeners for settlement of solids. Flocculation polymers systems are generally installed to aid settlement. The overflow from the thickener is discharged to the plant sewers and the underflow from the thickeners is passed through filters for decanting with the filtrate being returned to the thickener while the filter cake is sent to the sintering plant for recycling. These systems can become recycling systems by adding make-up water to compensate for water evaporation in the primary quencher.

The treated water is pumped into the venturi scrubber and recycled from the venturi scrubber to the primary quencher.

The thickener overflow produces an effluent of 30-50 mg/l but can be reduced further by means of pressure sand filters to 5 to 10 mg/l.

An alternate wet system to the venturi scrubber system is the wet gas washer and disintegration system. This system has a limited use due to the limited volume and horsepower required to operate the disintegrator. Disintegrators operate in the range of 170 to 2000 cu m/min (6,050 to 70,600 cu ft min) at 448 kw which would require six to seven units for an average 200 kkg (220 ton) BOF furnace.

The effluent from this system is discharged to a thickener and water is recycled to gas washers.

The off gas system uses this similar quencher and venturi scrubber similar to the open hood combustion type system. The aqueous discharges from the off gas quenchers pass through a classifier, cyclone separator and from there to a thickener where the thickener overflow is recycled back to the scrubber system. The underflow is decanted by filters and the filter cake is returned to the sintering plant.

Plant Visits

Five basic oxygen plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 39 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

Plant R - Figure 46

This plant utilizes chemical coagulation, sedimentation, and complete recycle to treat waste waters generated from their gas cleaning system. There is zero aqueous discharge from the system.

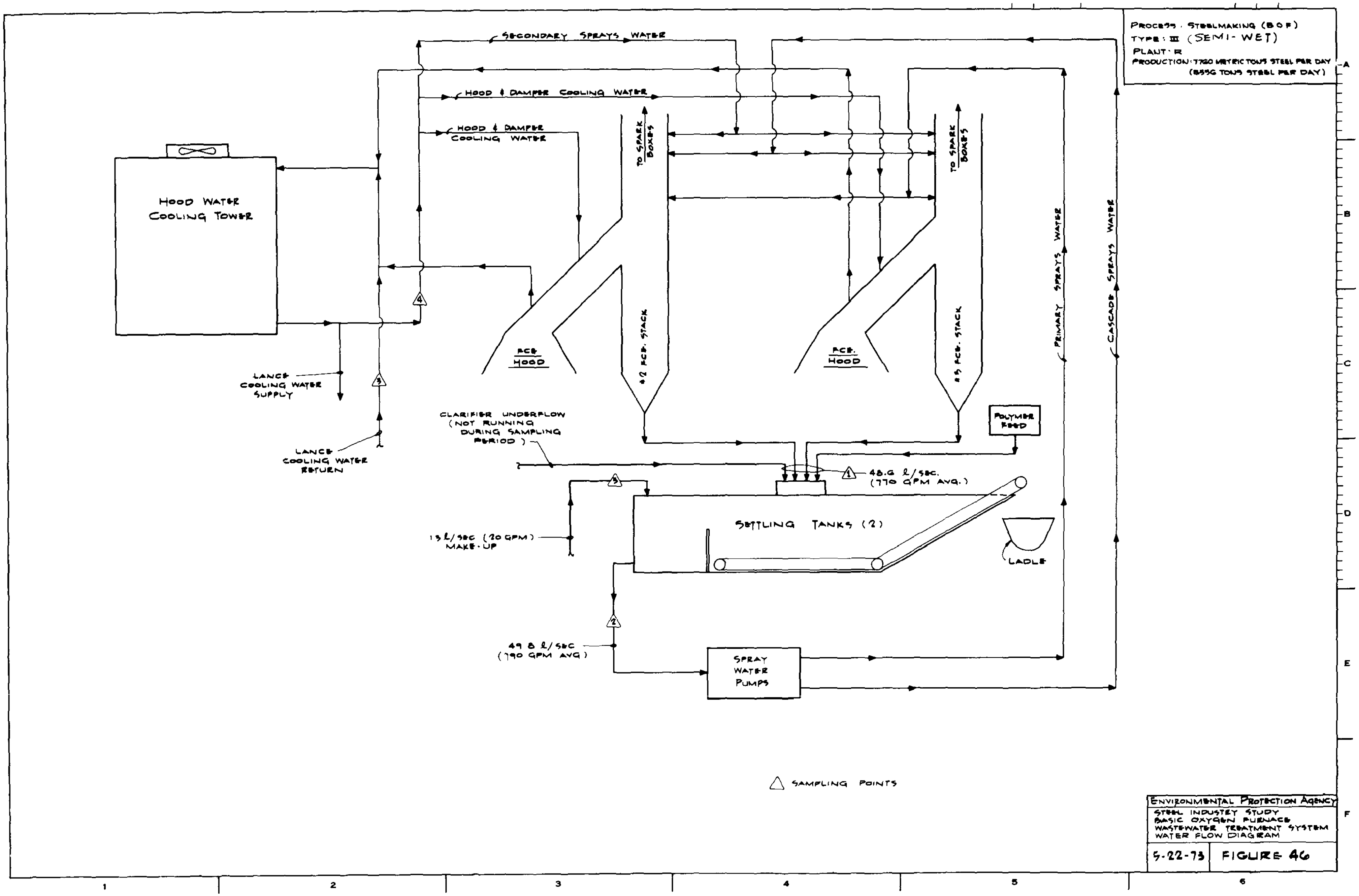
Plant S - Figure 47

This plant utilizes classification, thickening, and recycle with blowdown (approximately 5%) to treat waste waters generated from their gas cleaning system.

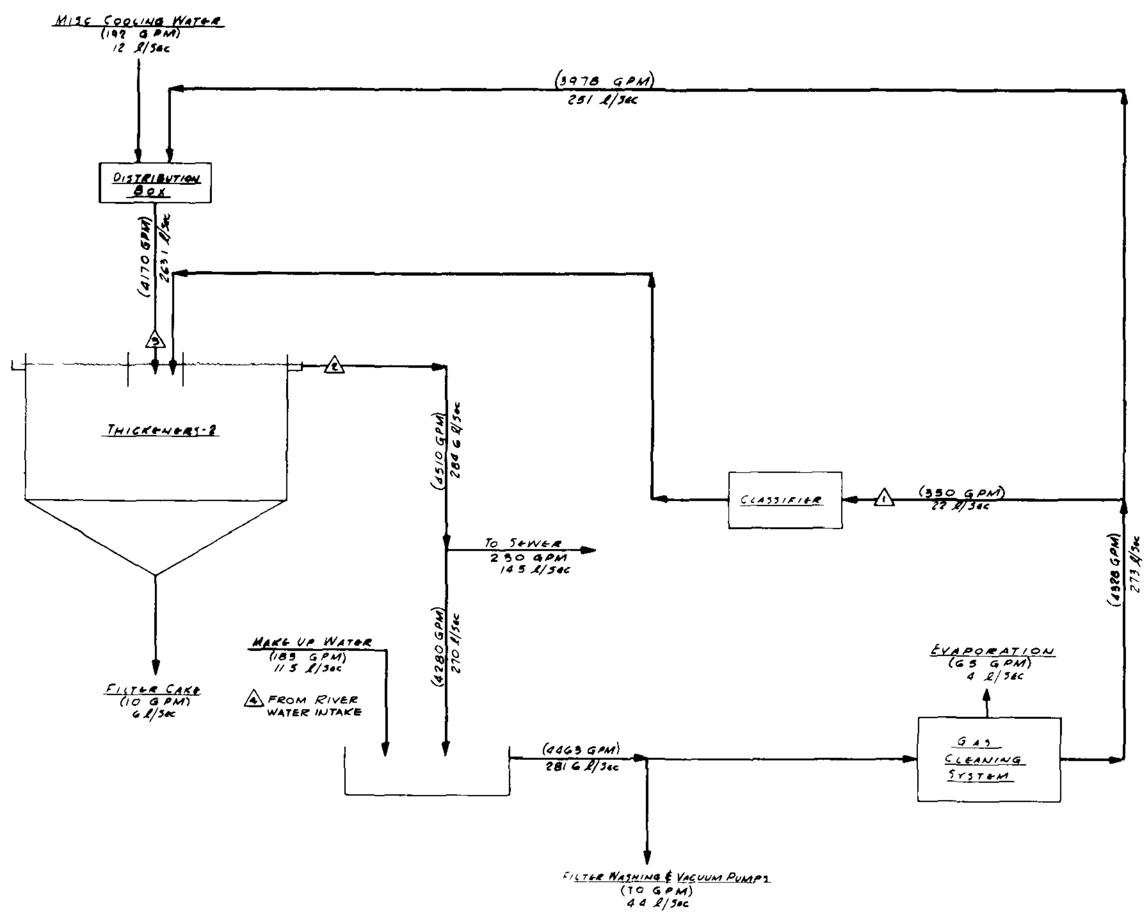
Gross plant effluent loads are 220 l/kkg of steel (52.2 gal/ton) flow, and 0.00478 kg suspended solids per kkg (lb/1,000 lb) of steel produced.

Overall percent removal of suspended solids associated with this system is 99.4%.

Plant T - Figure 48


PROCESS: STEELMAKING (BOF)
TYPE: III (SEMI-WET)
PLANT: R
PRODUCTION: 7760 METRIC TONS STEEL PER DAY
(8556 TONS STEEL PER DAY)
SECONDARY SPRAYS WATER
HOOD & DAMPER COOLING WATER
HOOD & DAMPER COOLING WATER
HOOD WATER COOLING TOWER
TO SPARK BOXES
TO SPARK BOXES
FCE. HOOD
FCE. HOOD
#2 FCE. STACK
#5 FCE. STACK
PRIMARY SPRAYS WATER
CASCADE SPRAYS WATER
LANCE COOLING WATER SUPPLY
LANCE COOLING WATER RETURN
CLARIFIER UNDERFLOW (NOT RUNNING DURING SAMPLING PERIOD)
POLYMER FEED
48.6 l/sec. (770 GPM AVG.)
SETTLING TANKS (2)
LADLE
13 l/sec (20 GPM) MAKE-UP
49.8 l/sec (790 GPM AVG)
SPRAY WATER PUMPS
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-22-73
FIGURE 46

PROCESS STEELMAKING (BOF)
TYPE II (WET)
PLANT S
PRODUCTION: 5755.8 METRIC TONS STEEL PER DAY
(6346 TONS STEEL PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-9-73 | FIGURE 47

This plant utilizes classification, thickening, and recycle with blowdown (approximately 25%) to treat waste waters generated in their gas cleaning system.

Gross plant effluent loads are 915 l/kkg of steel (217 gal/ton) flow, and 0.064 kg suspended solids, and 0.0129 kg fluoride per kkg (lb/1,000 lb) of steel produced.

Overall removal of suspended solids and fluoride associated with this system is 99.34% and 59.2%, respectively.

Plant U - Figure 49

This plant utilizes chemical coagulation and thickening, followed by direct discharge of all waste waters generated by their gas cleaning system.

Gross plant effluent loads are 3,060 l/kkg of steel (728 gal/ton) flow, and 0.115 kg suspended solids, and 0.0114 kg fluoride per kkg (lb/1,000 lb) of steel produced.

Overall removal of suspended solids and fluoride are 91% and 0.0%, respectively.

Plant V - Figure 50

This plant utilizes classification, chemical coagulation, thickening, and recycle with blowdown (approximately 13%) to treat waste waters generated in the gas cleaning system.

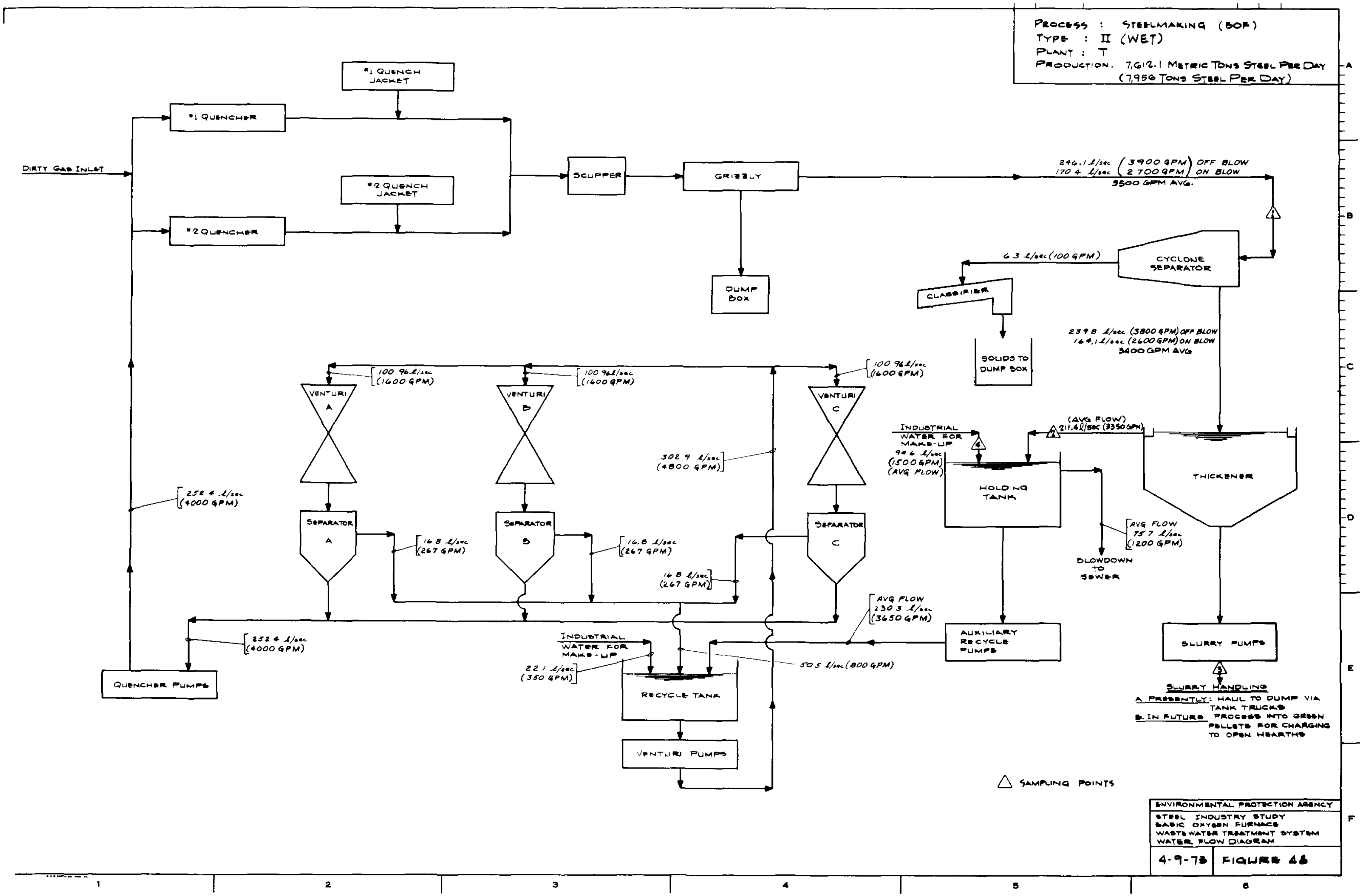
Gross plant effluent loads are 139 l/kkg of steel (33.3 gal/ton) flow, and 0.0055 kg suspended solids and 0.00298 kg fluoride per kkg (lb/1,000 lb) of steel produced.

Overall removal of suspended solids and fluoride amounted to 99.94% and 0%, respectively.

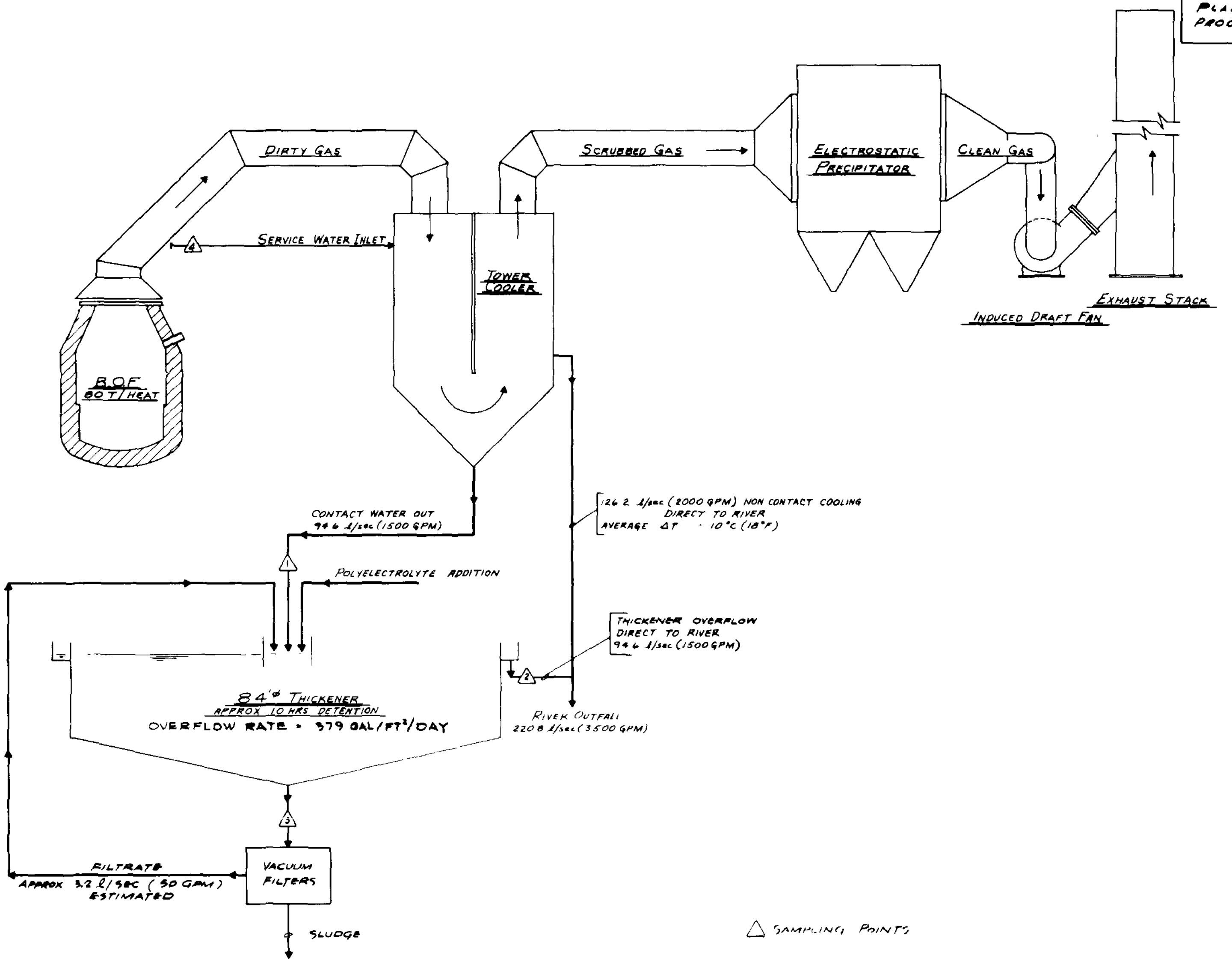
Open Hearth Furnace Operation

Either wet high energy venturi scrubber systems or dry precipitator systems are installed on open hearth shops. The hot gases to the precipitator systems are conditioned by either passing the gases through evaporation chambers or through waste heat boilers, reducing the gas temperature from 1600°F to 500°F. Because the open hearth furnaces are fired using many available fuels, nitrous oxides and sulfur oxides are present in the waste gas streams.

The aqueous discharges from precipitators are zero except for any waste heat boiler blowdown.

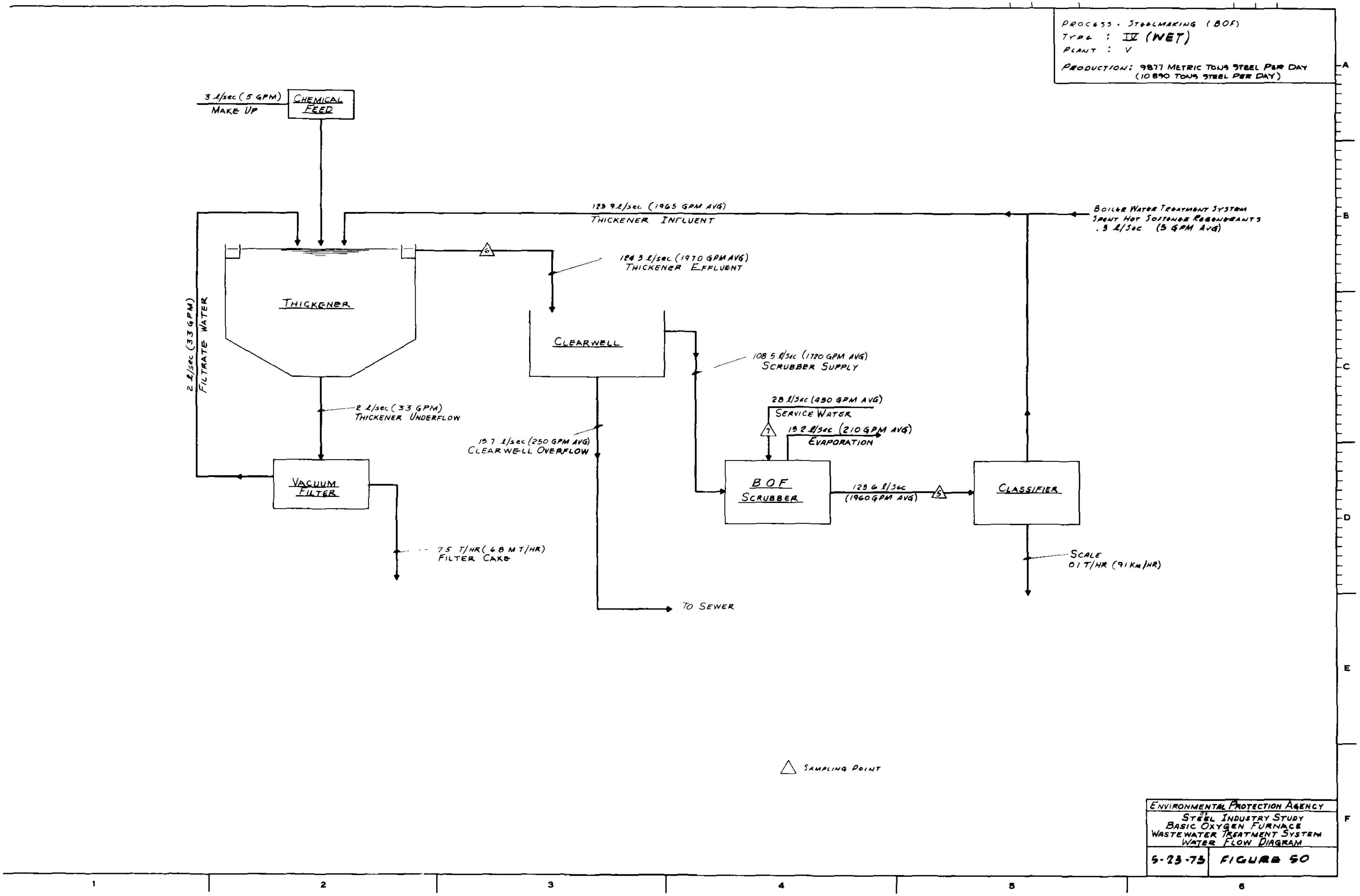

PROCESS : STEELMAKING (BOF)
TYPE : II (WET)
PLANT : T
PRODUCTION. 7,612.1 METRIC TONS STEEL PER DAY
(7,956 TONS STEEL PER DAY)
DIRTY GAS INLET
#1 QUENCHER
#2 QUENCHER
#1 QUENCH JACKET
#2 QUENCH JACKET
SCUPPER
GRIZZLY
DUMP BOX
246.1 l/sec (3900 GPM) OFF BLOW
170.4 l/sec (2700 GPM) ON BLOW
3500 GPM AVG.
CYCLONE SEPARATOR
6.3 l/sec (100 GPM)
CLASSIFIER
SOLIDS TO DUMP BOX
239.8 l/sec (3800 GPM) OFF BLOW
164.1 l/sec (2600 GPM) ON BLOW
3400 GPM AVG
THICKENER
(AVG FLOW) 211.4 l/sec (3350 GPM)
INDUSTRIAL WATER FOR MAKE-UP
94.6 l/sec (1500 GPM) (AVG FLOW)
HOLDING TANK
AVG FLOW 75.7 l/sec (1200 GPM)
BLOWDOWN TO SEWER
SLURRY PUMPS
SLURRY HANDLING
A. PRESENTLY: HAUL TO DUMP VIA TANK TRUCKS
B. IN FUTURE: PROCESS INTO GREEN PELLETS FOR CHARGING TO OPEN HEARTHS
AUXILIARY RECYCLE PUMPS
AVG FLOW 230.3 l/sec (3650 GPM)
100.96 l/sec (1600 GPM)
100.96 l/sec (1600 GPM)
100.96 l/sec (1600 GPM)
VENTURI A
VENTURI B
VENTURI C
302.9 l/sec (4800 GPM)
SEPARATOR A
SEPARATOR B
SEPARATOR C
16.8 l/sec (267 GPM)
16.8 l/sec (267 GPM)
16.8 l/sec (267 GPM)
252.4 l/sec (4000 GPM)
252.4 l/sec (4000 GPM)
QUENCHER PUMPS
INDUSTRIAL WATER FOR MAKE-UP
22.1 l/sec (350 GPM)
50.5 l/sec (800 GPM)
RECYCLE TANK
VENTURI PUMPS
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
4-9-73
FIGURE 46

PROCESS : STEELMAKING (BOF)
TYPE : II (SEMI-WET)
PLANT : U
PRODUCTION : 2691 METRIC TONS STEEL PER DAY
(2967 TONS STEEL PER DAY)



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-2-73 FIGURE 49


PROCESS : STEELMAKING (BOF)
TYPE : IV (WET)
PLANT : V
PRODUCTION: 9877 METRIC TONS STEEL PER DAY
(10890 TONS STEEL PER DAY)
3 l/sec (5 GPM)
MAKE UP
CHEMICAL FEED
123.9 l/sec (1965 GPM AVG)
THICKENER INFLUENT
BOILER WATER TREATMENT SYSTEM
SPENT HOT SOFTENER REGENERANTS
.3 l/sec (5 GPM AVG)
124.3 l/sec (1970 GPM AVG)
THICKENER EFFLUENT
THICKENER
CLEARWELL
2 l/sec (33 GPM)
FILTRATE WATER
108.5 l/sec (1720 GPM AVG)
SCRUBBER SUPPLY
2 l/sec (33 GPM)
THICKENER UNDERFLOW
28 l/sec (450 GPM AVG)
SERVICE WATER
13.2 l/sec (210 GPM AVG)
EVAPORATION
15.7 l/sec (250 GPM AVG)
CLEARWELL OVERFLOW
VACUUM FILTER
BOF SCRUBBER
123.6 l/sec
(1960 GPM AVG)
CLASSIFIER
7.5 T/HR (6.8 M T/HR)
FILTER CAKE
SCALE
.01 T/HR (.91 Km/HR)
TO SEWER
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-23-75
FIGURE 50

The aqueous discharges from the high energy venturi scrubbers system is scrubbing waters from the primary quenchers.

The aqueous discharges are treated the same as the BOF except pH adjustment has to be added to adjust for the acidic wastes being discharged.

Plant Visits

Two open hearth shops were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 40 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the waste water treatment systems are presented.

Plant W - Figure 51

This plant utilizes thickening and recycle with blowdown (approximately 16%) to treat waste waters generated in their gas cleaning system.

Gross plant effluent loads from the system are 216 l/kkg of steel (51.4 gal/ton) flow, and 0.0173 kg of suspended solids, 0.0316 kg fluoride, 0.00471 kg nitrate, and 0.0057 kg zinc per kkg (lb/1,000 lb) of steel produced.

Overall removals for suspended solids, fluoride, nitrate, and zinc are 98.27%, 42.37%, 91.28%, and 0.0%, respectively.

Plant X - Figure 52

This plant utilizes chemical coagulation, thickening, and recycle with blowdown (approximately 21%) to treat waste waters generated in their gas cleaning system.

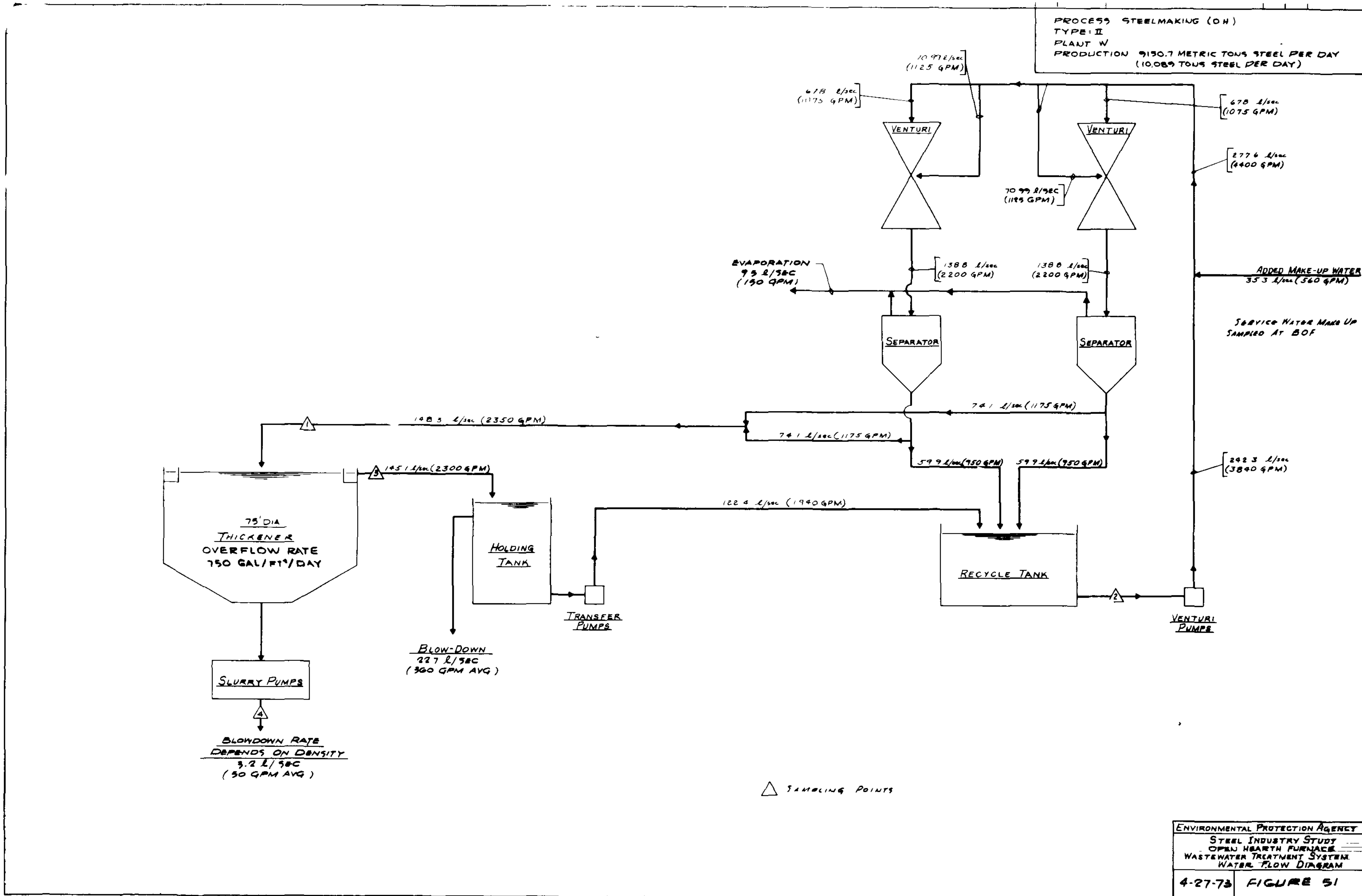
Gross plant effluent loads from the system are 500 l/kkg of steel (120 gal/ton) flow, and 0.0256 kg suspended solids, 0.032 kg fluoride, 0.030 kg nitrate, and 0.595 kg zinc per kkg (lb/1,000 lb). of steel produced.

Overall removals for suspended solids, fluoride, nitrate, and zinc are 99.7%, 10%, 0.0%, and 70.47%, respectively.

Electric Arc Furnace Operation

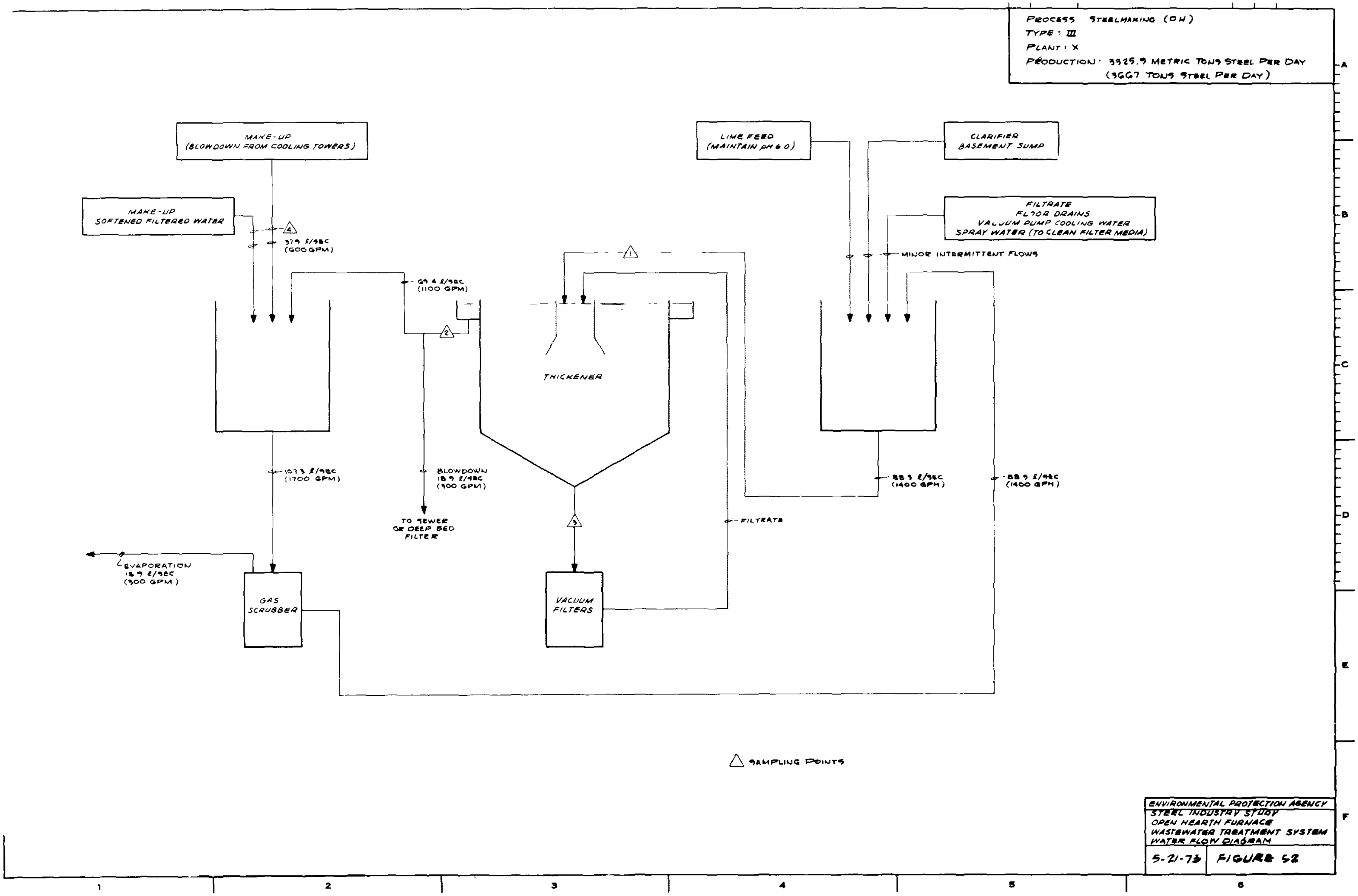
The furnace collection systems range from a complete dry to semi-wet to wet high energy venturi scrubbers.

The dry fume collection system consists of baghouses with local exhaust or plant rooftop exhaust hoods. The aqueous discharges from these systems are zero.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

4-27-73 FIGURE 51



PROCESS STEELMAKING (OH)
TYPE: III
PLANT: X
PRODUCTION: 3925.9 METRIC TONS STEEL PER DAY (3667 TONS STEEL PER DAY)
MAKE-UP (BLOWDOWN FROM COOLING TOWERS)
MAKE-UP SOFTENED FILTERED WATER
37.9 ℓ/SEC (600 GPM)
69.4 ℓ/SEC (1100 GPM)
LIME FEED (MAINTAIN pH 6.0)
CLARIFIER BASEMENT SUMP
FILTRATE
FLOOR DRAINS
VACUUM PUMP COOLING WATER
SPRAY WATER (TO CLEAN FILTER MEDIA)
MINOR INTERMITTENT FLOWS
THICKENER
107.3 ℓ/SEC (1700 GPM)
BLOWDOWN 18.9 ℓ/SEC (300 GPM)
TO SEWER OR DEEP BED FILTER
88.3 ℓ/SEC (1400 GPM)
88.3 ℓ/SEC (1400 GPM)
FILTRATE
EVAPORATION 18.9 ℓ/SEC (300 GPM)
GAS SCRUBBER
VACUUM FILTERS
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-21-73

FIGURE 52

The semi-wet system employs a spark box or spray chamber to condition the hot gases for either a precipitator or baghouse. A spark box is generally used with a precipitator system and spray chamber for a baghouse system. The spark box conditions the gases to 200°C while spray chamber conditions gases to 135°C. The aqueous discharge from these systems is controlled and treated with similar systems as used on the spark box chamber on the basic oxygen furnace.

The wet high energy venturi scrubber fume collection systems use the water cooled elbow for extracting the gases from the electric arc furnace. Combustion air gaps are always left between the water cooled elbow and fume collection ductwork to insure that all the CO gas burns to CO2 before entering the high energy venturi scrubber or any other fume collection cleaning device. As the hot gases pass through the scrubber, the gases are conditioned and cooled to 182°F saturation temperature.

The aqueous discharge from the wet scrubber system is handled in the same manner as the BOF.

Plant Visits

Four electric furnace shops were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 41 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

Plant Y - Figure 53

This plant utilizes chemical coagulation, magnetic flocculation, sedimentation, and total recycle to treat those waste waters generated in the gas cleaning system.

The system has zero aqueous discharge.

The system effects 100% removal of fluoride and suspended solids.

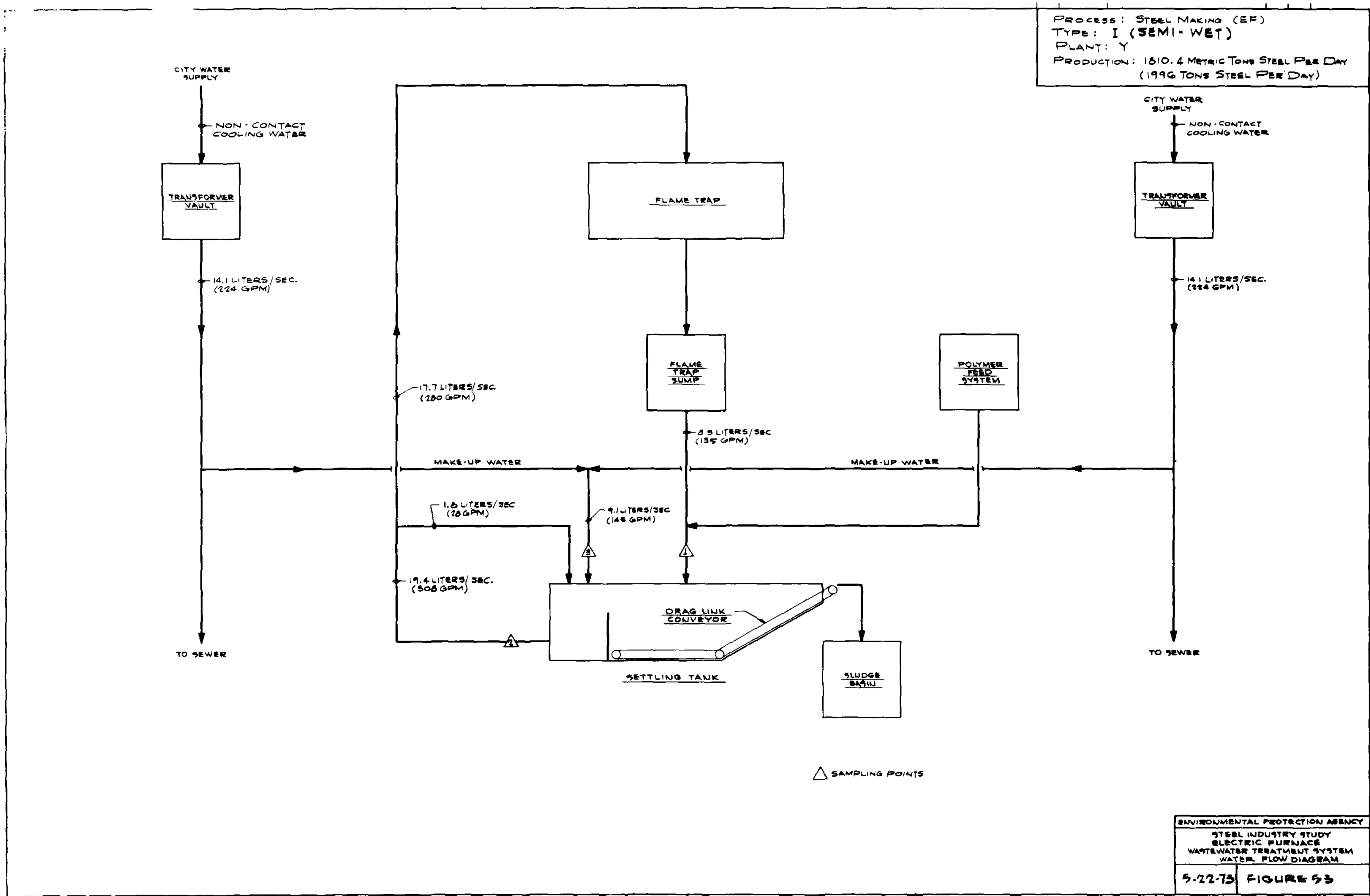
Plant Z - Figure 54

This plant utilizes closely controlled moisture addition to their gas cleaning system to produce a sludge of sufficient solids concentration to allow direct solids disposal.

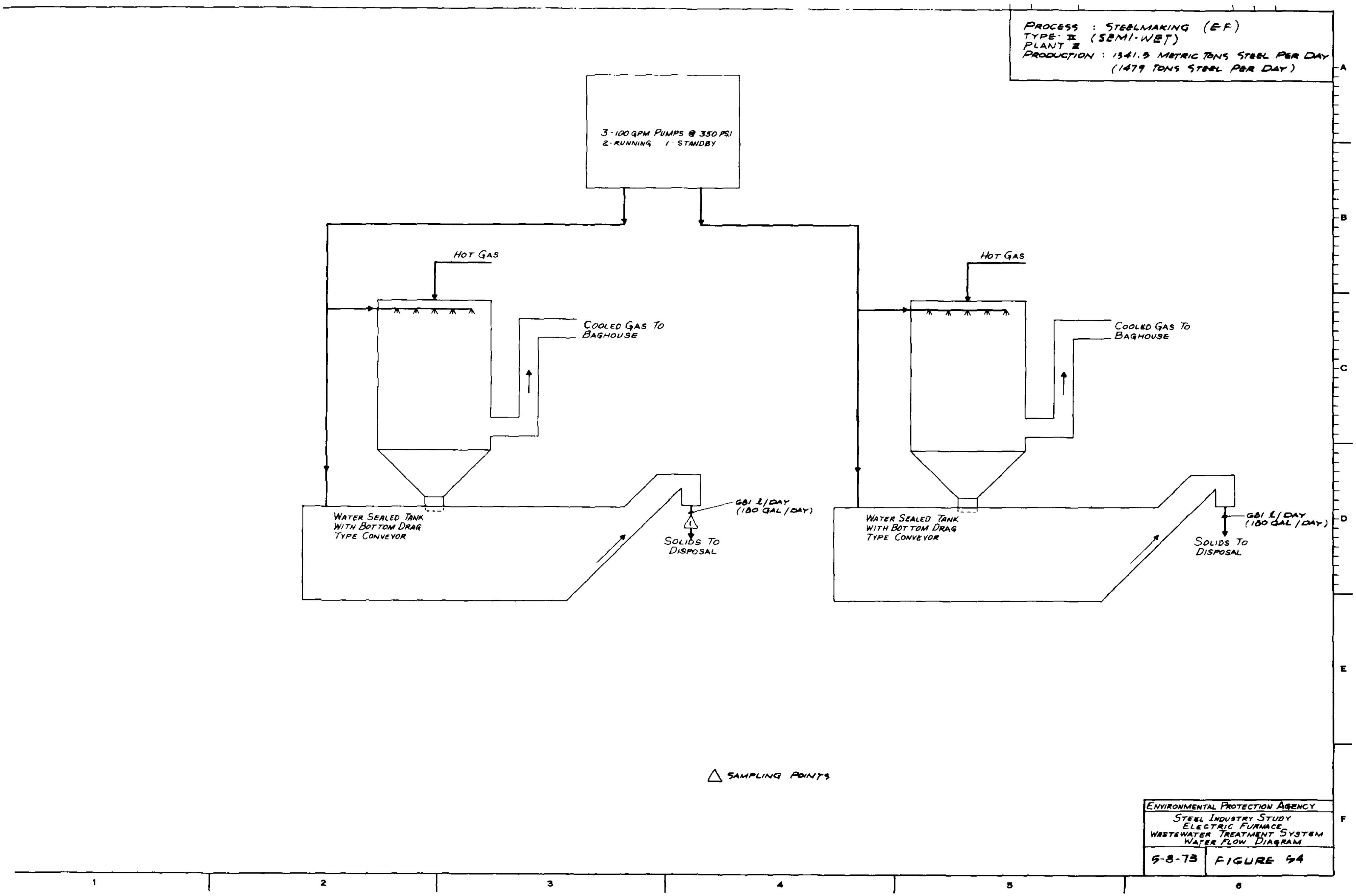
There is no aqueous discharge from the system.

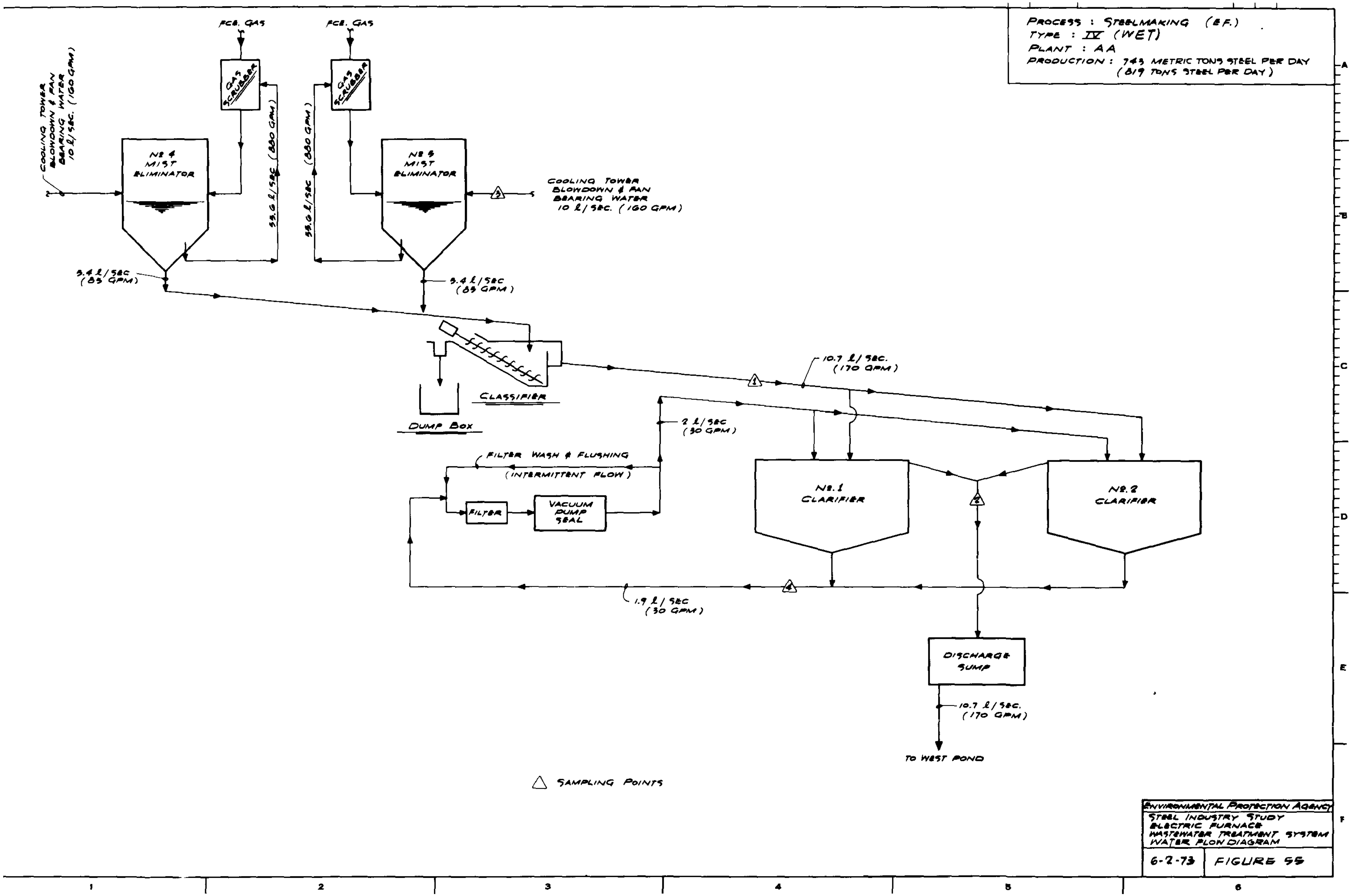
The system effects 100% removal of suspended solids.

Plant AA - Figure 55



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-22-73
FIGURE 53


PROCESS : STEELMAKING (EF)
TYPE II (SEMI-WET)
PLANT II
PRODUCTION : 1341.3 METRIC TONS STEEL PER DAY
(1479 TONS STEEL PER DAY)
3-100 GPM PUMPS @ 350 PSI
2-RUNNING 1-STANDBY
HOT GAS
COOLED GAS TO BAGHOUSE
WATER SEALED TANK WITH BOTTOM DRAG TYPE CONVEYOR
681 l/DAY (180 GAL/DAY)
SOLIDS TO DISPOSAL
HOT GAS
COOLED GAS TO BAGHOUSE
WATER SEALED TANK WITH BOTTOM DRAG TYPE CONVEYOR
681 l/DAY (180 GAL/DAY)
SOLIDS TO DISPOSAL
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
5-8-73
FIGURE 54


PROCESS : STEELMAKING (E.F.)
TYPE : IV (WET)
PLANT : AA
PRODUCTION : 743 METRIC TONS STEEL PER DAY
(819 TONS STEEL PER DAY)
FCE. GAS
FCE. GAS
GAS SCRUBBER
GAS SCRUBBER
COOLING TOWER BLOWDOWN & FAN BEARING WATER 10 l/SEC. (160 GPM)
No. 4 MIST ELIMINATOR
No. 5 MIST ELIMINATOR
55.6 l/SEC (880 GPM)
55.6 l/SEC (880 GPM)
COOLING TOWER BLOWDOWN & FAN BEARING WATER 10 l/SEC. (160 GPM)
5.4 l/SEC (85 GPM)
5.4 l/SEC (85 GPM)
CLASSIFIER
DUMP BOX
10.7 l/SEC. (170 GPM)
2 l/SEC (30 GPM)
FILTER WASH & FLUSHING
(INTERMITTENT FLOW)
FILTER
VACUUM PUMP SEAL
No. 1 CLARIFIER
No. 2 CLARIFIER
1.9 l/SEC (30 GPM)
DISCHARGE SUMP
10.7 l/SEC. (170 GPM)
TO WEST POND
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
6-2-73
FIGURE 55

This plant utilizes classification and clarification on a once-through basis to treat waste waters generated in the gas cleaning system.

Gross plant effluent loads from the system are 1,220 l/kkg of steel (299 gal/ton) flow, and 0.0258 kg fluoride and 0.074 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Overall removals of fluoride and suspended solids observed are 0% and 97.3%, respectively.

Plant AB - Figure 56

This plant utilizes recycle with blowdown (approximately 6%), with treatment of the blowdown via thickening and extended settling to treat waste waters generated in the gas cleaning system.

Gross plant effluent loads are 680 l/kkg of steel (162 gal/ton) flow, and 0.0081 kg fluoride, and 0.015 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Net overall removals of fluoride and suspended solids are 7.8% and 99.95%, respectively.

Vacuum Degassing Operation

The condensed steam and heated cooling water is discharged from the barometric condenser in a hot well. The water from the hot well is either discharged or is routed into a combination water treatment system that services other steelmaking facilities. The water rate for the barometric condensers systems is approximately 85-175 l/sec (20 - 41 gal/sec) with temperature increases of 20-30°C. Inert gases, for example argon, are injected for mixing of bath and nitrogen is used for purging the system before breaking the vacuum.

Plant Visits

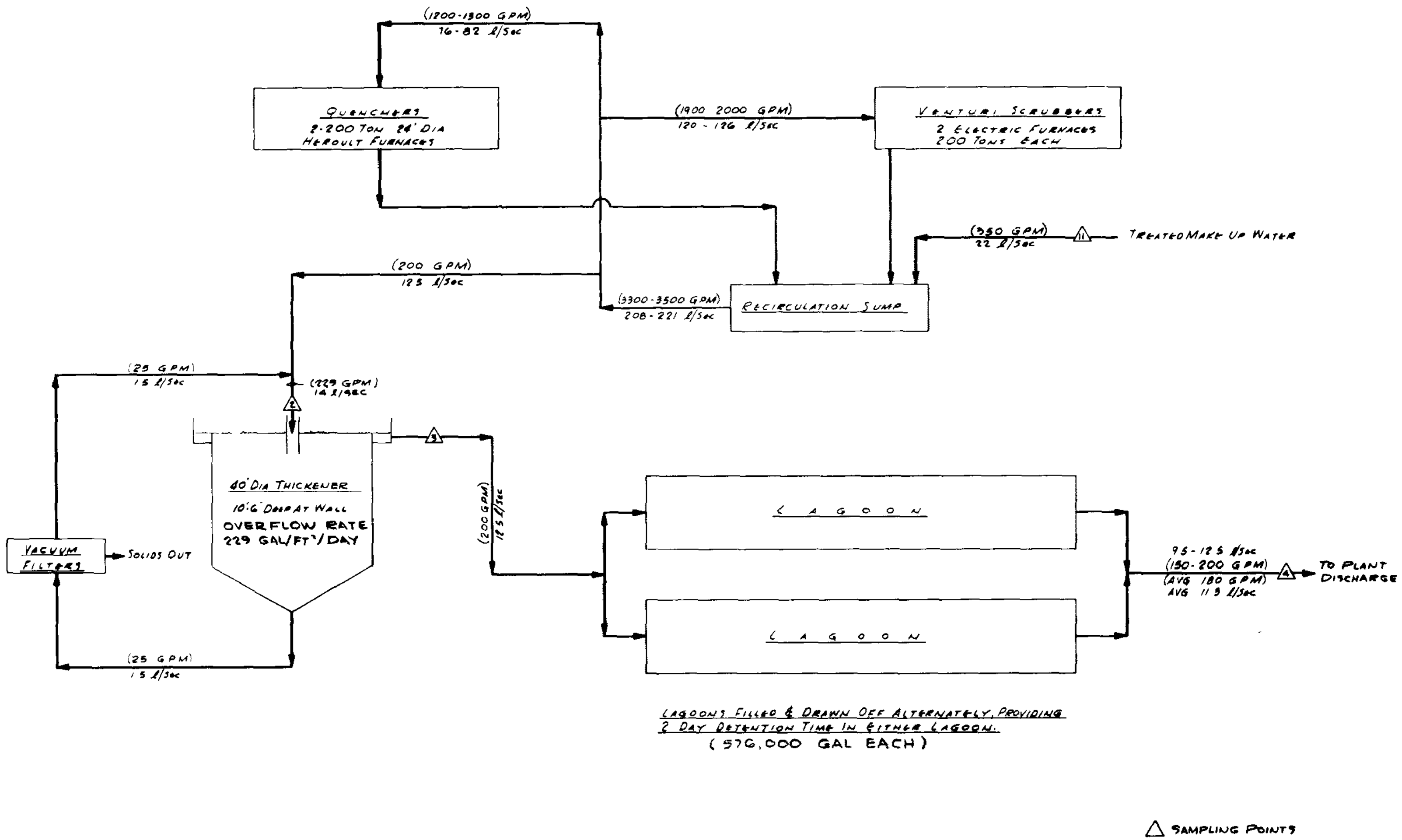
Two degassing plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 42 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility.

Plant AC - Figure 57

Vacuum degasser waste water or tight recycle loop with minimal blowdown. Loop contains cooling tower for heat dissipation.

Normal gross effluent waste load is estimated to be 67 l/kkg of steel (16 gal/ton) flow, 10,900 Btu of heat per kkg (9,940 Btu/ton) and 0.00011 kg lead, 0.0012 kg manganese 0.0068 kg nitrate, 0.0035 kg

PROCESS: STEELMAKING (EF)
TYPE IV (WET)
PLANT AB
PRODUCTION 1451.2 METRIC TONS STEEL PER DAY
(1600 TONS STEEL PER DAY)

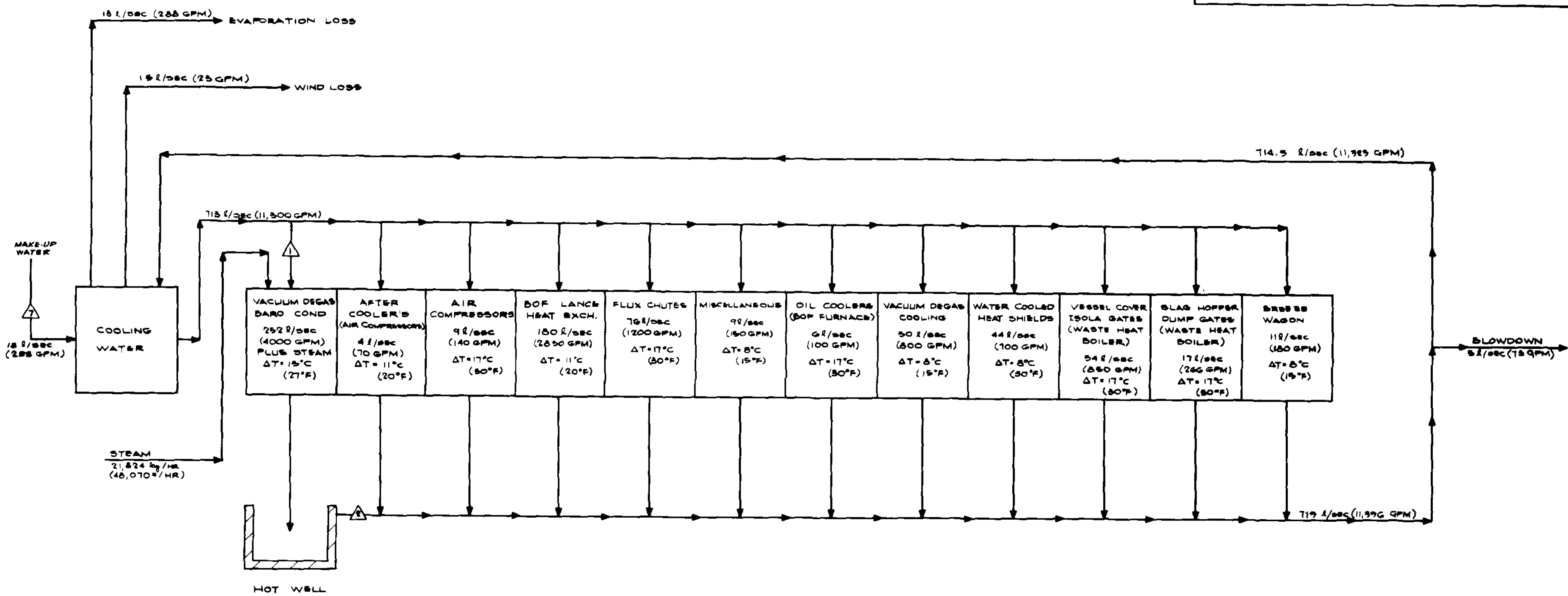


ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-2-73

FIGURE 56

PROCESS VACUUM DEGASSING
PLANT AC
PRODUCTION 5944.5 METRIC TONS STEEL PER DAY
(6554 TONS STEEL PER DAY)



COOLING TOWER SYSTEM - DEGASSING AND BOP

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSING
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-23-73

FIGURE 57

suspended solids, and 0.0015 kg zinc per kkg (lb/1,000 lb) of steel processed.

Overall removals of heat, lead, manganese, nitrate, suspended solids and zinc are 72.4%, 93.4%, 92.9%, 94.6%, 96.0% and 79.4%, respectively.

Plant AD - Figure 58

Degasser waste water is on a moderately tight recycle loop with scale pit, filter, and cooling tower.

Normal gross effluent waste load is estimated to be 46 l/kkg of steel (10.9 gal/ton) flow, 220 Btu/kkg (182 Btu/ton), and 0.0000046 kg lead, 0.000127 kg manganese, 0.0 kg nitrate, 0.00168 kg suspended solids, and 0.0000416 kg zinc per kkg (lb/1,000 lb) of steel processed.

Overall removals of heat, lead, manganese, nitrate, suspended solids, and zinc are 98.8%, 99.6%, 100%, 94.9%, 97.1% and 99.4% respectively.

Continuous Casting Subcategory

The spray water system water discharge is an open recirculating system with make-up and blowdown using either settling chamber scale pits with drag link conveyors or flat bed type filters for scale and oil removal. The effluent from the scale pit or filtrate from the flat bed filters is sometimes reduced in temperature by pumping through induced draft cooling towers before recycling the waters back to the spray system. Approximately 5-10% of the spray water is evaporated during the spray of the cast product. The aqueous discharge from this system is blowdown.

Plant Visits

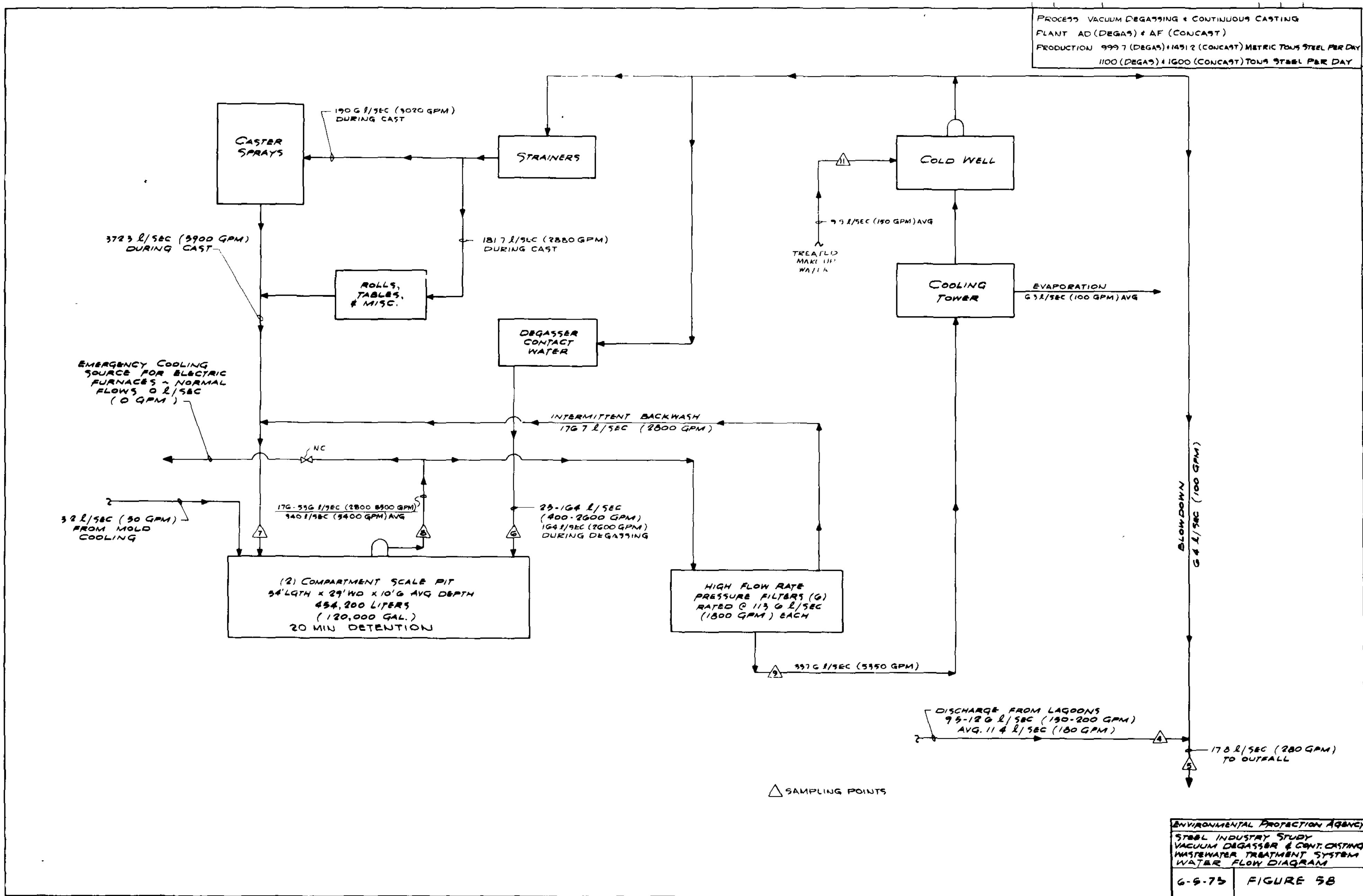
Two continuous casting plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 43 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility.

Plant AE - Figure 59

Caster waste water is on a moderately tight recycle loop. The loop contains scale pit, filter, and cooling tower.

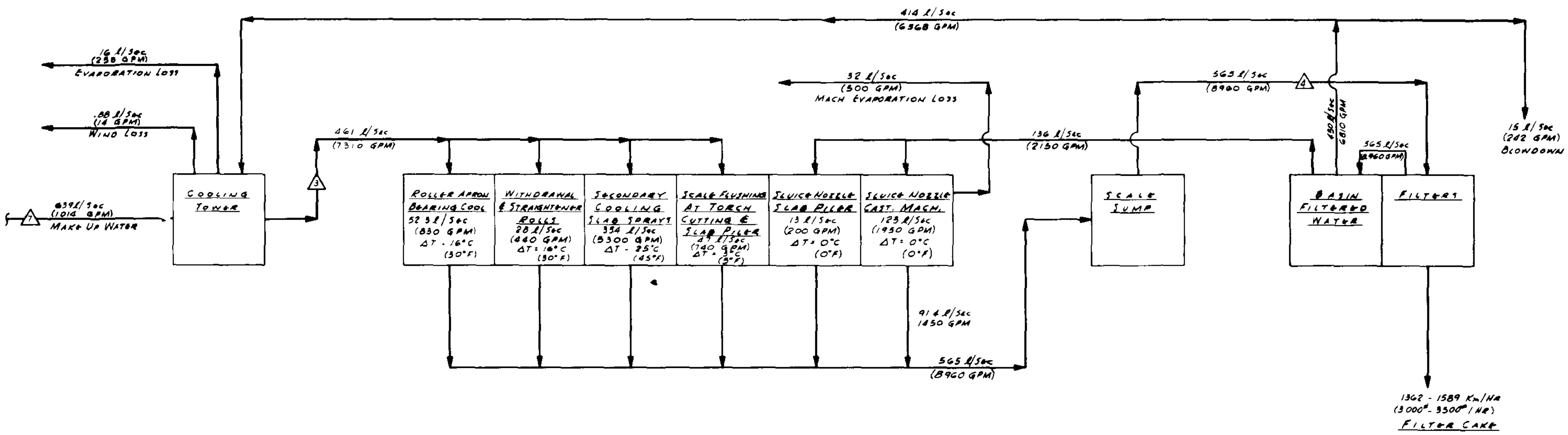
Normal gross plant effluent waste load is estimated to be 467 l/kkg of steel (111 gal/ton) flow, and 0.0020/kg oil and grease, and 0.00202 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Overall removals of oil and grease and suspended solids are 99.4% and 98.7%, respectively.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSER & CONT. CASTING
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
6-5-75
FIGURE 58

Process: Continuous Casting
Plant: A6
Production: 2845 Metric Tons Steel Per Day (3137 Tons Steel Per Day)



Environmental Protection Agency
Steel Industry Study
Continuous Casting
Wastewater Treatment System
Water Flow Diagram

5-21-73 FIGURE 59

Plant AF - Figure 58

Caster waste water is on a tight recycle system with minimal blowdown. Recycle loop contains scale pit, filter, and cooling tower.

Normal gross effluent waste load is estimated to be 344 l/kkg (82.5 gal/ton) of steel flow, with less than 0.000172 kg oil and grease and 0.0127 kg suspended solids per kkg (lb/1.000 lb) of steel produced.

Overall removals of oil and grease and suspended solids are 99.9% and 97.2%, respectively.

These results are summarized in Tables 44 through 53.

Base Level of Treatment

In developing the technology, guidelines, and incremental costs associated with the application of the technologies subsequently to be selected and designated as one approach to the treatment of effluents to achieve the BPCTCA, BATEA, and NSPS effluent qualities, it was necessary to determine what base or minimum level of treatment was already in existence for practically all plants within the industry in any given sub-category. The different technology levels were then formulated in an "add-on" fashion to these base levels. The various treatment models (levels of treatment) and corresponding effluent volumes and characteristics are listed in Tables 54 through 64. Since these tables also list the corresponding costs for the average size plant these tables are presented in Section VIII.

It was obvious from the plant visits that many of the plants in existence today have treatment and control facilities with capabilities that exceed the technologies chosen to be the base levels of treatment. Even though many plants may be superior to the base technology it was necessary, in order to be all inclusive of the industry as a whole, to start at the base level of technology in the development of treatment models and incremental costs.

SECTION VIII

COST, ENERGY, AND NONWATER QUALITY ASPECTS

Introduction

This section will discuss the incremental costs incurred in applying the different levels of pollution control technology. The analysis will also describe energy requirements, nonwater quality aspects (including sludge disposal, by-product recovery, etc.), and their techniques, magnitude, and costs for each level of technology.

It must be remembered that some of the technology beyond the base level may already be in use. Also many possible combinations and/or permutations of various treatment methods are possible. Thus, not all plants will be required to add all of the treatment capabilities or incur all of the incremental costs indicated to bring the base level facilities into compliance with the effluent limitations.

Costs

The water pollution control costs for the plants visited during the study is presented in Tables 44 through 53. The treatment systems, gross effluent loads and reduction benefits were described in Section VII. The costs were estimated from data supplied by the plants. The results are summarized as follows:

Subcategory		Plant	Cost per unit weight of product		
			$/kkg	$/ton	Product
I	By Product Coke	A	0.855	0.776	Coke
		B	0.118	0.107	Coke
		C	0.789	0.716	Coke
		D	0.847	0.769	Coke
II	Beehive Coke	E	*0.074	*0.068	Coke
		F	*0.039	*0.036	Coke
		G	0.023	0.021	Coke
III	Sintering	J	NA	NA	Sinter
IV	Blast Furnace (Iron)	L	1.033	0.937	Iron
		M	0.122	0.111	Iron
		N	0.172	0.156	Iron
		O	1.022	0.927	Iron
V	Blast Furnace (FeMn)	Q	4.220	3.830	FeMn
VI	BOF (Semi Wet)	R	0.160	0.145	Steel
		U	0.161	0.146	Steel
VII	BOF (Wet)	S	0.176	0.160	Steel
		T	** 0.052	**0.047	Steel

TABLE 44
WATER EFFLUENT TREATMENT COSTS
Coke Making - By-Products
I-A

PLANT	A	B	C	D		RANGE
INITIAL INVESTMENT	$ 2,352,200	$ 699,100	$ 4,000,000	$ 2,000,000		
ANNUAL COSTS						
COST OF CAPITAL	99,700	29,600	169,500	84,800		
DEPRECIATION	235,200	69,900	400,000	200,000		
OPER & MAINT	140,300	46,100	137,700	174,100		
ENERGY & POWER	966,100	28,200	848,200	4,400		
TOTAL	$ 1,441,300	$ 173,800	$ 1,555,400	$ 463,300		
$/TON	0.776*	0.107	0.716	0.769		0.107 - 0.776
$/1000 GAL TRT	5.59	0.843	19.4	19.6*		0.843 - 19.6

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	A lb/TON	A mg/l	B lb/TON	B mg/l	C lb/TON	C mg/l	D lb/TON	D mg/l	lb/TON	mg/l	Range lb/TON	Range mg/l
Flow(gal/TON)	139	-	127	-	37	-	4600	-			37 - 4600	-
Ammonia	2.20	1900	1.46	1380	2.26	7330	1.49	39			1.46 - 2.26	39 - 7330
BOD_5	1.79	1550	1.35	1280	0.346	1120	0.456	12			0.346 - 1.79	12 - 1550
Cyanide	0.118	102	0.120	110	0.0282	91	0.293	7.7			0.0282 - .293	7.7 - 110
Phenol	0.519	[illegible]	0.374	350	0.279	910	0.232	6.1			0.232 - 0.519	6.1 - 910
Oil & Grease	-		0.254	240	0.0314	101	0.082	2.1			0.0314 - 0.254	2.1 - 240
Suspended Solids	-	-	0.0381	36	0.130	421	0.880	23			0.0381 - 0.880	23 - 421
Sulfide	-	-	0.665	629	0.0606	197	0.161	4.2			0.0606 - 0.665	4.2 - 629

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	A lb/TON	A mg/l	B lb/TON	B mg/l	C lb/TON	C mg/l	D lb/TON	D mg/l	lb/TON	mg/l	Range lb/TON	Range mg/l
Flow (gal/TON)	153		108		41		4600				41-4600	
Ammonia	1.22	958	1.04	1160	0.159	471	0.07	1.8			0.07-1.22	1.8-1160
BOD_5	0.0816	64.1	0.0204	22.7	0.181	537	0.192	5			0.0204-0.192	5-537
Cyanide	0.123	96.4	0.0339	37.7	0.0230	68	0.311	8.1			0.0230-0.311	8.1-96.4
pH		8.5		7.5		9.5-11.8		7.5				7.5-11.8
Phenol	0.00174	1.37	0.0000575	0.0639	0.0741	219	0.002	0.0521			0.0000575-0.0741	0.0521-219
Oil & Grease			0.00225	2.5	0.00632	18.7	0.000768	0.02			0.000768-0.00632	0.02-18.7
Sulfide			0.000234	0.26	0.0382	113	0.0576	1.5			0.0382-2.34	0.26-113
Suspended Solids			0.147	163	0.0348	103	0.269	7.0			0.0348-0.269	7.0-163

[illegible] actual volume treated 39.3 gal/TON

TABLE 45
WATER EFFLUENT TREATMENT COSTS
Coke Making - Beehive
I-B

PLANT	E	F	G			RANGE
INITIAL INVESTMENT	$ 4000	$ 7500	$ 19,500			
ANNUAL COSTS:						
COST OF CAPITAL	170	320	830			
DEPRECIATION	400	750	1950			
O & M & MAINT	24,100	12,000	1200			
ENERGY & POWER	0	0	680			
TOTAL	$ 24,670	$ 13,070	$ 4660			
$/TON	0.0676	0.0358	0.0207			0.0207 - 0.0676
$/1000 GAL TPT	0.138	0.0731	0.169			0.0731 - 0.169

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETER	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/ton)	490	-	490	-	123	-					123 - 490	-
Ammonia	0.00134	0.33	0	0	0	0					0 - 0.00134	0 - 0.33
BOD5	0.0122	3.0	0	0	0	0					0 - 0.0122	0 - 3.0
Cyanide	0.0000082	0.002	0	0	0	0					0 - 0.0000082	0 - 0.002
Phenol	[illegible]	[illegible]	0	0	0	0					0 - 0.0000449	0 - 0.01
Suspended Solids	-		0.12	29	0.74	722					0.12 - 0.74	29 - 722

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETER	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/ton)	[illegible]		0	-	0	-					0-490	
Ammonia	[illegible]	0.24	[illegible]	[illegible]	0	0					0-0.00098	0-0.24
BOD_5	[illegible]	1.00	0	0	0	0					0-0.00408	0-1.0
Cyanide	[illegible]	[illegible]		0	0	0					0-0.0000163	0-0.00404
pH		[illegible]										
Phenol	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]					0-0.0000571	0-0.0140
Suspended Solids	[illegible]	[illegible]	[illegible]	0	0	0					0-0.147	0-36.01

TABLE 46
WATER EFFLUENT TREATMENT COSTS
Burden Preparation - Sintering
II-A

PLANT	H	J				RANGE
INITIAL INVESTMENT	N/A	$ 500,000				
ANNUAL COSTS:						
COST OF CAPITAL		21,200				
DEPRECIATION		50,000				
OPER & MAINT		N/A				
ENERGY & POWER		N/A				
TOTAL	N/A	$ 71,200+				
$/TON		0.0770+				
$/1000 GAL TRT		0.226+				

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	104	-	341								104 - 341	
Fluoride	0.000554	0.644	-0.0425	-14.9							-0.0425 - 0.000554	-14.9 - 0.644
Oil	0.437	504	1.30	457							0.437 - 1.3	450 - 500
Sulfide	0.163	188	0.183	64.4							0.163 - 0.183	64.4 - 1.88
Suspended Solids	3.76	4340	55.4	19500							3.76 - 55.4	4300 - 19500

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow	No flow data		114									
Fluoride			0.008055	8.5								
Oil & Grease			0.000947	1.0								
pH		9.6		12.8								
Sulfide			0.01022	10.8								
Suspended Solids			0.00853	9								

TABLE 47
WATER EFFLUENT TREATMENT COSTS
Iron Making - Fe Blast Furnace

TRT CONTROL TECH	L	M	N	O		RANGE
INITIAL INVESTMENT	$ 3,650,000	$ 1,000,000	$ 641,300	$ 3,275,000		
ANNUAL COSTS:						
COST OF CAPITAL	154,700	42,400	27,200	138,800		
DEPRECIATION	365,000	100,000	64,100	327,500		
OPER & MAINT	120,600	N/A	28,000	95,200		
ENERGY & POWER	180,900	N/A	3,300	Incl.		
TOTAL	$ 821,200	$ 142,400+	$ 122,600	$ 561,500		
$/TON	0.937	0.111+	0.156	0.927		0.111+ - 0.937
$/1000 GAL TRT	0.174	0.0576+	0.0467	0.297		0.0467 - 0.297

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	5400	-	1930	-	3350	-	3123	-			1930 - 5400	
Ammonia	0.0636	1.41	0.0628	3.9	0.272	9.75	0.321	12.3			0.0628 - 0.321	1.41 - 12.3
Cyanide	0.0647	1.44	0.0138	0.858	-0.00672	-0.241	-0.00602	-0.231			-0.00672 - 0.0647	-0.241 - 1.44
Fluoride	0.0205	0.454	-0.00071	-0.044	0.0604	2.16	-0.0673	-2.59			-0.0673 - 0.0604	-2.59 - 2.16
Phenol	0.0260	0.578	-0.0104	-0.643	0.0148	0.530	0.00222	0.0853			-0.0104 - 0.0260	-0.643 - 0.578
Sulfide	0.195	4.34	0.623	38.8	-0.0125	-0.448	-0.0296	-1.14			-0.0296 - 0.623	-1.14 - 38.8
Suspended solids	77.6	1720	10.5	651	8.57	307	30.3	1170			8.57 - 77.6	307 - 1720

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	24000		123		101		104				101 - 24,000	
Ammonia	0.169	0.943	0.0799	78	0.223	265	0.0867	100			0.0799-0.223	0.843-265
Cyanide	[illegible]	[illegible]	[illegible]	17	0.0157	18.6	0.00937	10.8			0.001-0.0174	0.005-18.6
Fluoride	0.0980	0.49	0.0230	23	0.00874	10.4	0.0191	22			0.00874 - 0.0980	0.49-23
pH		7.7		7.8		7.2		7.7				7.2 - 7.8
Phenol	[illegible]	[illegible]	[illegible]	3.59	[illegible]	[illegible]	[illegible]	0.01			0.0000087 0.00368	0.010 - 3.59
Sulfide	[illegible]	0.042	[illegible]	[illegible]	0.00350	4.16	0.00598	6.9			0.00350-0.00860	[illegible] -6.9
Suspended solids	[illegible]	[illegible]	[illegible]	[illegible]	0.0327	38.8	0.0399	46			0.0327-2.2	[illegible]

NOTE: This is [illegible] to [illegible] and slag quenchers and BOF hood spray, but not to a receiving stream.

TABLE 48

WATER EFFLUENT TREATMENT COSTS

Iron Making - Fe-Mn Blast Furnace

III-B

PLANT	Q					RANGE
INITIAL INVESTMENT	$ 2,215,000					
ANNUAL COSTS:						
COST OF CAPITAL	93,900					
DEPRECIATION	221,500					
OPERATION & MAINT	406,300					
ENERGY & POWER	90,200					
TOTAL	$ 811,900					
$/TON	3.83					
$/1000 GAL TRT	0.495					

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	7730											
Ammonia	7.35	114										
Cyanide	1.52	23.6										
Manganese	55.0	833										
Phenol	0.00836	0.130										
Sulfide	-0.171	-2.66										
Suspended Solids	322	5000										

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	5700											
Ammonia	7.83	165										
Cyanide	5.08	107										
Manganese	0.287	6.05										
pH		8.7										
Phenol	0.0219	0.46										
Sulfide	4.84	102										
Suspended Solids	2.56	54										

TABLE 49
WATER EFFLUENT TREATMENT COSTS
Steelmaking - Basic Oxygen
IV-A

PLANT	R	S	U	V	T	RANGE
INITIAL INVESTMENT	$ 400,000	$ 1,730,000	$ 1,108,000	$ 5,382,000	N/A	
ANNUAL COSTS:						
COST OF CAPITAL	16,900	73,300	46,900	227,600	N/A	
DEPRECIATION	40,000	173,000	110,800	538,200	N/A	
OPER & MAINT	395,000	72,200	N/A	411,300	$ 7,800	
ENERGY & POWER	INCL.	52,800	N/A	INCL.	128,800	
TOTAL	$ 451,900	$ 371,300	$ 157,700	$ 1,177,100	$136,600	
$/TON	0.145	0.160	0.146	0.296+	0.0470	0.0470+ - 0.296
$/1000 GAL TRT	1.11	0.157	0.200+	1.14+	0.0765	0.0765+ - 1.14

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	R lb/TON	R mg/l	S lb/TON	S mg/l	U lb/TON	U mg/l	V lb/TON	V mg/l	T lb/TON	T mg/l	RANGE lb/TON	RANGE mg/l
Flow (gal/TON)	130	-	1020	-	728	-	259	-	615	-	130 - 1020	-
Fluoride	-	-	-	-	0.0143	2.36	0.00596	2.76	0.0560	10.9	0.00596 - 0.0560	2.36 - 10.9
Suspended Solids	0.348	321	1.53	180	2.40	396	11.5	5330	19.1	3730	0.348 - 19.1	180 - 5330

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	R lb/TON	R mg/l	S lb/TON	S mg/l	U lb/TON	U mg/l	V lb/TON	V mg/l	T lb/TON	T mg/l	RANGE lb/TON	RANGE mg/l
Flow(gal/TON)	No Discharge		52.2		728		33		217		0-728	
Fluoride			-	-	0.0227	3.75	-	-	0.0257	14.5	0.0227-0.0257	3.75-14.5
pH				9.3		12		6.4		9.4		6.4-12
Suspended Solids			0.00956	22	0.230	38	0.0110	40	0.127	70.5	0.00956-0.230	22-70.5

TABLE 50
WATER EFFLUENT TREATMENT COSTS
Steelmaking - Open Hearth
IV-B

PLANT	W		X								RANGE	
INITIAL INVESTMENT	$ 974,000		$ 1,925,000									
ANNUAL COSTS:												
COST OF CAPITAL	41,300		81,600									
DEPRECIATION	97,400		192,500									
OPER & MAINT	7,600+		138,500									
ENERGY & POWER	128,600		6,200									
TOTAL	$ 274,900+		$ 418,800									
$/TON	0.0746+		0.313								0.0746+- 0.313	
$/1000 GAL TPT	0.123+		0.569								0.123+- 0.569	

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETER	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	607	-	550	-							550 - 607	-
Fluoride	0.108	21.4	0.0742	16.2							0.0742 - 0.108	16.2 - 21.4
Nitrate	0.102	20.2	0.152	33.2							0.102 - 0.152	20.2 - 33.2
Suspended Solids	1.96	388	17.8	3880							1.96 - 17.8	388 - 3880
Zinc	0.0104	2.06	4.03	880							0.0104 - 4.03	2.06 - 880

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETER	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	51.4		118								51.4-118	
Fluoride	0.0632	148	0.0639	65							0.0632-0.0639	65-148
Nitrate	0.00942	22	0.298	303							0.00942-0.298	22-303
pH		3.4-1.8		6.1								
Suspended Solids	0.0345	80	0.0511	52							0.0345-0.0511	52-80
Zinc	0.0113	26.5	1.19	1210							0.0113-1.19	26.5-1210

TABLE 51
WATER EFFLUENT TREATMENT COSTS
Steelmaking - Electric
IV-C

PLANT	Y	Z	AA	AB		RANGE
INITIAL INVESTMENT	$ 341,000	$ 133,300	$ 338,500	$ 1,250,000		
ANNUAL COSTS:						
COST OF CAPITAL	14,500	5,700	14,300	53,000		
DEPRECIATION	34,100	13,300	33,900	125,000		
OPER & MAINT	5,600	3,100	89,200	343,900		
ENERGY & POWER	15,800	600	INCL.	-		
TOTAL	$ 70,000	$ 22,700	$ 137,400	$ 521,900		
$/TON	0.0961	0.0420	0.460	0.894		0.0420 - 0.894
$/1000 GAL TRT	0.986	172	1.54	4.96		0.986 - 172

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	97.4	-	0.243	-	299	-	180	-			0.243 - 299	-
Fluoride	-0.0233	-28.7	-	-	0.0369	14.8	0.0169	11.3			-0.0233 - 0.0369	-28.7 - 14.8
Suspended Solids	0.700	863	1.57	77.4%	5.38	2160	64.2	42,800			0.700 - 64.2	863 - 77.4%

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (Gal/TON)					299		162				0 - 299	
Fluoride	No		No		0.0515	20.7	0.0162	12			0-0.0515	0-20.7
pH	Discharge		Discharge			7.9		7.9				
Suspended Solids					0.144	58	0.0310	23			0-0.144	0-58

TABLE 52
WATER EFFLUENT TREATMENT COSTS
Degassing
V

PLANT	AC	AD				RANGE
INITIAL INVESTMENT	$ 508,000	$ 187,400				
ANNUAL COSTS:						
COST OF CAPITAL	21,500	7,900				
DEPRECIATION	50,800	18,700				
OPER & MAINT	38,800	51,600				
ENERGY & POWER	INCL.	INCL.				
TOTAL	$ 111,100	$ 78,200				
$/TON	0.0464	0.195				0.0572 - 0.195
$/1000 GAL TRT	0.0516	0.999				0.0636 - 0.999

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	900	-	195	-							195 - 900	-
Lead	0.00353	0.471	0.00227	1.39							0.00227 - 0.00353	0.471 - 1.39
Nitrate	0.190	25.3	0.00492	3.03							0.00492 - 0.190	3.03 - 25.3
Manganese	0.0429	5.72	0.0217	13.3							0.0217 - 0.0429	5.72 - 13.3
Suspended Solids	0.174	23.2	0.115	70.7							0.115 - 0.174	23.2 - 70.7
Zinc	0.0151	2.01	0.0126	7.76							0.0126 - 0.0151	2.01 - 7.76

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	16		10.9								10.9-16	
Lead	0.000224	1.67	0.0000091	<0.1							0.0000091- 0.000224	<0.1- 1.67
Manganese	0.00232	17.4	0.000253	2.79							0.000253- 0.00232	2.79- 17.4
Nitrate	0.0137	103	0.0	0.0							0.0-0.0137	0.0-103
pH		6.2		7.7-6.8								6.2-7.7
Suspended Solids	0.00710	53	0.00336	37							0.00336-0.00710	37- 53
Zinc	0.00312	23.3	0.0000832	0.916							0.0000832-0.00312	0.916-23.3

TABLE 53
WATER EFFLUENT TREATMENT COSTS
Continuous Casting
VI

PLANT	AE	AF				RANGE
INITIAL INVESTMENT	$ 2,314,000	$ 2,062,600				
ANNUAL COSTS:						
COST OF CAPITAL	97,900	87,200				
DEPRECIATION	231,400	206,300				
OPER & MAINT	176,900	567,400				
ENERGY & POWER	INCL	INCL				
TOTAL	$ 506,200	$ 860,900				
$/TON	0.442	1.47				0.442 - 1.47
$/1000 GAL TRT	0.108	.999				0.108 - 0.999

AVERAGE NET PLANT RAW WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	4110		1480								1480 - 4110	
Oil and Grease	0.703	20.5	0.270	22.0							0.270 - 0.703	20.5 - 22.0
Suspended Solids	0.270	7.87	0.909	74.0							0.270 - 0.909	7.87 - 74.0

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

PARAMETERS	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l	lb/TON	mg/l
Flow (gal/TON)	111		82.5								82.5-111	
Oil & Grease	0.00402	4.35	<0.000344	<0.5							<0.000344 - 0.00402	<0.5-4.35
pH		6.8		7.7-6.8								6.8-7.7
Suspended Solids	0.00403	4.36	0.0254	37							0.00403- 0.0254	4.36-37

		V	0.326	0.296	Steel
VIII	Open Hearth	W	0.083	0.075	Steel
		X	0.345	0.313	Steel
IX	Electric Arc (Semi-Wet)	Y	0.106	0.096	Steel
		Z	0.046	0.042	Steel
X	Electric Arc (Wet)	AA	0.507	0.460	Steel
		AB	0.985	0.894	Steel
XI	Vacuum Degassing	AC	0.051	0.046	Steel
		AD	0.215	0.195	Steel
XII	Continuous Casting	AE	0.487	0.442	Steel
		AF	1.620	1.470	Steel

* Capital recovery cost only, operating cost not available
** Total operating cost less capital recovery

The results are summarized as follows:

Base Level and Intermediate Technology, Energy, and Nonwater Impact

The base levels of treatment and the energy requirements and nonwater quality aspects associated with intermediate levels of treatment are discussed below by subcategories.

By Product Coke

1. Base Level of Treatment: Phenol removal and free-leg ammonia stripping of ammonia liquor in a once through system. Pond for suspended solids removal. Once through noncontact primary cooler effluent and tight final cooler recycle system with blowdown to dephenolizer. Benzol waste to dephenolizer and pH neutratization by addition of acid.

2. Additional energy requirements:

   a. Treatment Alternative I:

   Additional power will be required to improve the quality of the effluent of the waste water treatment system used in fume cleaning of the by-product coke process to meet the anticipated 1977 standards. The additional energy utilized will be 0.22 kwh/kkg (0.20 kwh/ton) of coke produced. For the typcial 2,414 kkg/day (2,660 ton/day) facility the additional power required will be 21.63 kw (29 hp). The additional operating cost for this addition will be approximately $2,175.00.

b. Treatment Alternative II:

TABLE 54

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

EGORY/SUBCATEGORY: By-Product Coke

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
Ammonia liquor treatment via free still only; dephenolizer; settling pond for solids; light oil recovered for sale to outside contractors; quench water recycles with no blowdown; final cooler water recycles with blowdown to dephenolizer; crystalizer barometric condenser water once-through to settling pond.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	1000 5 90 300 25 20 50 6-9	Widely practiced in industry. Subject to upsets from slug loads. Fair.	Requires constant attention to maintenance & housekeeping. Heated discharges	6 months	1 acre (200' x 200')	Quenching with contaminated water, releases volatiles to air.	Coke fines are useable in plant. Solids to landfill.
ternate I - Physical/ emical To (A), add lime and steam to fixed leg of ammonia still; neutralize prior to settling.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	125 2 30 150 10 15 50 6-9	Used by some plants in industry. Good.	Same as in (A). Lime addition requires care in handling.	6 months	1 acre (200' x 200')	Volatile compounds released to air.	Same as in (A), with additional sludge from lime addition.

isted in order of increasing effectiveness

TABLE 54 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

EGORY/SUBCATEGORY: By-Product Coke

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
To (B), add aeration; aggressive chemical oxidation; neutralization; break point chlorination; clarification and/or filtration; carbon adsorption. Recycle crystallizer effluent through final cooler water recycle system.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	10 0.5 0.25 20 0.3 10 10 6-9	Chemical oxidation practiced at some blast furnace (iron) plants; other technology from chemical, refining & water treatment industries. Very good.	Part of technology untested on coke plant wastes. Very close control of intermediate steps must be practiced.	1-3 years	1-1/2 acre (200' x 400')	Volatile compounds released to air.	Same as (A), with additional sludge from neutralization steps.
ternate II - Biological To (A), add lime and steam to fixed leg of ammonia still; abandon dephenolizer; neutralize; add single stage bio-oxidation for phenol removal.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	125 1 20 100 1.0 10 50 6-9	Used by some some plants in industry. Good.	Same as in (A). Lime addition requires care in handling.	6 months	1 acre (200' x 200')	Volatile compounds released to air.	Same as in (A), with additional sludge from neutralization steps.

Listed in order of increasing effectiveness

TABLE 54 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: By-Product Coke

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
. To (B), add aeration; multistage biological treatment; neutralization; and filtration; recycle crystallizer effluent through final cooler water recycle system.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	10 0.5 0.25 20 0.3 10 10 6-9	Single-stage biological oxidation practiced at some coke plants; other technology from chemical, refining & water treatment industries. Very good.	Part of technology untested on coke plant wastes. Very close control of intermediate steps must be practiced.	1-3 years	1-1/2 acre (200' x 400')	Volatile compounds released to air.	Same as (A), with formation of biological sludges added.
. As an option to (A), (B), and (C) above, distillation of all partly detarred gases and liquids by controlled combustion. No liquid discharges.	NH_3 Phenol CN^- BOD_5 $S^=$ O&G SS pH	0 0 0 0 0 0 0 -	Used at some coke plants. Effective elimination of waste load from water, but transfers load to air.	Can be done only at plants where impact on air quality can be tolerated. Of limited application	8-12 months	1/2 acre (100' x 200')	High impact on air quality.	Formation of ashes.

Listed in order of increasing effectiveness

TABLE 54 (cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

By Product Coke Subcategory
Alternate I - Physical/Chemical

Treatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BATEA C	D(1)
Investment	4,482,074	168,460	666,930	1,738,426
Annual Costs:				
Capital	192,729	7,299 (2)	28,678	74,751
Depreciation	448,207	28,077 (2)	66,693	173,843
Operation & Maintenance	156,872	5,896	23,342	60,844
Carbon Column Rental	-	-	245,400	-
Sludge Disposal	13,897	13,897	1,620	-
Energy & Power	15,000	2,175	37,500	600
Chemical	1,942	46,090	139,500	1,205,000
Steam Generation	32,400	48,600	-	-
TOTAL	861,047	152,034	542,733	1,515,038

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	175	175	175	100	0
Ammonia, mg/l	2,000	1,000	125	10	0
Phenol, mg/l	360	5	2	0.5	0
Cyanide, mg/l	200	90	30	0.25	0
BOD_5, mg/l	1,200	300	150	20	0
Sulfide, mg/l	400	25	10 (3)	0.3	0
Oil & Grease, mg/l	120	20	15	10	0
Suspended solids, mg/l	90	50	50	10	0
pH	6-9	6-9	6-9	6-9	-

(1) Incremental to capital costs and depreciation for Level A

(2) Based on 6 year depreciation rate to allow for conversion to biological for BATEA.

(3) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

TABLE 54 (cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

By Product Coke Subcategory
Alternate II - Biological

reatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BATEA C	
ıvestment	4,482,094	(440,610)(1) 462,610	494,716	
ınual Costs:				
Capital	192,729	(18,946)(1) 19,892	21,272	
Depreciation	448,207	(44,061)(1) 46,261	49,472	
Operation & Maintenance	156,872	16,191	17,314	
Sludge Disposal	13,897	14,127	-	
Energy & Power	15,000	31,500	22,500	
Chemical	1,942	68,406	4,248	
Steam Generation	32,400	48,600	-	
TOTAL	861,047	244,977 241,831(1)	114,806	

fluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	175	175	175	100	
Ammonia, mg/l	2000	1000	125	10	
Phenol, mg/l	360	5	1	0.5	
Cyanide, mg/l	200	90	20	0.25	
BOD_5, mg/l	1200	300	100	20	
Sulfide, mg/l	400	25	1.0 (2)	0.3	
Oil & Grease, mg/l	120	20	10	10	
Suspended solids, mg/l	90	50	50	10	
pH	6-9	6-9	6-9	6-9	

(1) This assumes that neutralization has already been installed ($22,000) in preparation for meeting BPCTCA with physical-chemical treatment

(2) Value expected of typical treatment plant utilizing BPCTCA treatment technology

The additional energy utilized will be 3.12 kwh/kkg (2.83 kwh/ton) of coke produced. For the typical 2,414 kkg/day (2,660 ton/day) facility, the additional power required will be 313.32 kw (420 hp). The annual operating cost for this addition to the installation will be approximately $31,500.00.

3. Non-Water Quality Aspects (Both Alternates):

   a. Air Pollution: There are two potential types of emissions of air pollution significance in a typical coke plant. These are associated with the following major components or operations of the by-products recovery equipment:

      i tar collection from the flushing system

      ii free NH3 recovery in an ammonia still

      iii once through coke quenching with a sump for settling out fines

      iv once through final cooler

      The two types of emissions are volatile (gaseous) materials and suspended particulate matter. If a vapor recirculation or solvent extraction facility for dephenolization is added to the system, significant reductions in both parameters are achieved.

   b. Solid Waste Disposal: A number of different solid wastes are generated by treatment systems to upgrade the quality of the effluent from by-product coke oven fume cleaning. Among these are coke fines, tar sludges, dirty phenolates, blowdown sludge, lime sludge and sludges from the aeration lagoon. The coke fines are internally consumed through reuse in the mill and the tar sludges are further refined (usually by outside contractors) or are incinerated. The remaining solid waste products can best be disposed of as landfill.

Beehive Coke

1. Base Level of Treatment: Once through system with settling of the coke quench waters.

2. Additional Energy Requirements: Additional power will be necessary when bringing the quality of the effluent of the water treatment system used in the fume cleaning of the beehive coke making process up to the anticipated standard for 1977. The additional energy consumed will be 1.35 kwh/kkg (1.23 kwh/ton) of coke produced. For the typical 662.5 kkg/day (730 tons/day) facility, the additional power required will be 37.3 kw (50 hp). The annual cost for operating this new installation will be approximately $3,750.00.

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Beehive Coke

	Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
			mg/l						
.	Install settling pond to collect coke fines. No reduction in flows.	NH_3 $CN^=$ Phenol BOD_5 SS Temp pH	0.20 0.003 0.009 1.0 25 80°C 6-9	Practiced in this industry. Must be periodically cleaned of settled fines.	High thermal load	1 month	1/2 acre (100'x 200') for settling pond	By their very nature, beehives pollute air	Coke fines, which can be reused
.	Complete recycle - no aqueous blowdown. Make-up water required. Critical parameters reach equilibrium	Zero aqueous discharge		Widely practiced in this industry. Requires attention to prevent leaks or overloads	Higher operating temperatures Steam problems in winter.	2-4 months	No additional space compared with treatment Method A	Same as treatment Method A	Same as treatment Method A

Listed in order of increasing effectiveness

TABLE 55 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Beehive Coke Subcategory

Treatment or Control Technologies Identified under Item III of the Scope of Work:	A	B		
	BPCTCA-BATEA			
Investment	$ 99,024	$ 50,510		
Annual Costs:				
Capital	4,258	2,170		
Depreciation	9,902	5,051		
Operation & Maintenance	3,466	1,770		
Sludge Disposal	4,200			
Energy & Power		3,750		
TOTAL	$ 21,826	$ 12,741		

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	300	300	0		
Suspended solids, mg/l	400	25	0		
Ammonia, mg/l	0.35	0.20	0		
Cyanide, mg/l	0.004	0.003	0		
BOD_5, mg/l	3	1	0		
Phenol, mg/l	0.01	0.009	0		
pH	6-9	6-9	-		

3. Non-Water Quality Aspects

   a. Air Pollution: In beehive coke ovens, the items of air pollutional significance are gaseous emissions and suspended particulate matter which include smoke, dust, hydrogen sulfide, phenols and materials resulting from the destructive distillation of coal. If the system is tightened up, some of these contaminants can be washed out of the exhaust gases and the solids can be processed and utilized in ways outlined in the "Solid Waste Disposal" section.

   b. Solid Waste Disposal: Solid wastes will be generated by processing the scrub water and reusing coke fines in the system.

Sintering

1. Base Level of Treatment: Once through system consisting of treatment of waste water via a classifier and thickener with vacuum filter for solids dewatering.

2. Additional Power Requirements: To meet the anticipated 1977 standard utilizing a wet system in cleaning the emissions from the sinter process, modifications will be required to the waste water treatment system. The additional energy consumed will be 0.68 kwh/kkg (0.62 kwh/ton) of sinter produced. For the typical 2,704 kkg/day (2,980 tons/day) sinter plant, 223.8 kw (300 hp) will have to be added. The annual operating cost for the additional equipment will be $22,500.00.

3. Non-Water Quality Aspects

   a. Air Pollution: The main air pollution problem associated with the sinter process will be suspended particulate matter. Although the exhaust gases will be passed through a wash and 40% recycled, 0.1 kkg of particulate emission per kkg (lb/1,000 lb) of exhaust gas will be emitted into the atmosphere.

   b. Solid Waste Disposal: The solid waste from the waste system will be internally consumed in the sinter process.

Blast Furnace (Iron)

1. Base Level of Treatment: Once through system. Treatment system utilizes thickener with polyelectrolyte addition and vacuum filter for solids dewatering.

2. Additional Energy Requirements: To bring the quality of the effluent of the water treatment system utilized in the fume collection of the blast furnace (iron) process up to the anticipated

TABLE 56

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

ATEGORY/SUBCATEGORY: Sintering

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
A. Aqueous discharge from scrubber through classifier to thickener "once-through" Overflow to sewer, underflow through vacuum filters to Sinter Plant or land filled, filtrate recycled to thickener.	mg/l S.S. 40 O&G 45 $S^=$ 65 F^- 30 pH 8-10	Widely practiced, usually in conjunction with blast furnace operations. Dependable system.	No reduction of heat load or dissolved chemicals	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gasses	Solids consumed internally
B. Same as Item (A) except with chemical polymer flocculation in thickener.	mg/l S.S. 20 O&G 45 $S^=$ 65 F^- 30 pH 8-10	Usually included with blast furnace treatment system. Improves solids removal	No reduction of heat load or dissolved chemicals.	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gasses	Solids consumed internally

* Listed in order of increasing effectiveness

TABLE 56 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Sintering

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
C. Same as (B) except thickener overflow recycled to scrubber system with blowdown. Oil skimmer added to thickener. Add neutralization of blowdown.	S.S. O&G $S^=$ F^- pH	50 10 20 50 6-9	Recycle increases certain constituent concentrations but reduces loads.	No reduction of heat load. Increase in dissolved chemical concentrations.	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gases	Solids consumed internally
D. Same as Item (C) except blowdown treated through improved settling with aeration, lime treatment for F^-, neutralization, and sedimentation.	S.S. O&G $S^=$ F^- pH	25 10 0.3 20 6-9	$S^=$ & F^- removals practiced in other industries successfully. Process must be monitored	Requires close attention to treatment systems.	18 months	1-1/2 acre (200'x300')	Air: Particulate 0.1#/1000# exhaust gases	Solids consumed internally, and other solids to landfill
E. Same as Item (D) except additonal F^- removal via activated alumina treatment.	S.S. O&G $S^=$ F^- pH	10 3 0.3 5 6-9	F^- removal demonstrated on pilot scale; technology subject to scaling up to full size.	Requires close attention to treatment systems.	18 months	1-1/2 acre (200'x300')	Air: Particulates 0.1#/1000# exhaust gases	Solids consumed internally, and other solids to landfill

* Listed in order of increasing effectiveness

TABLE 56 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Sintering Subcategory

Treatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BPCTCA C	BATEA D	E
Investment	$ 548,150	$ 26,621	$228,315	$294,224	$ 221,
Annual Costs:					
Capital	23,570	1,145	9,818	12,652	9,
Depreciation	54,815	2,662	22,831	29,422	22,
Operation & Maintenance	19,185	932	7,991	10,298	7,
Sludge Disposal					
Energy & Power	12,450	675	7,050	14,775	
Chemical		2,000	713	1,360	
TOTAL	$ 110,020	$ 7,414	$ 48,403	$ 68,507	$ 40,

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels		BPCTCA		
Flow, gal/ton	250	250	250	50	50	50
Suspended solids, mg/l	8,000	40	20	50	25	10
Oil & grease, mg/l	600	45	45	10	10	3
Sulfide, mg/l	200	65	65	20 (1)	0.3	0.
Fluoride, mg/l	30	30	30	50 (1)	20	5
pH	8-10	8-10	8-10	6-9	6-9	6-

(1) Value that can be obtained utilizing BPCTCA treatment technology

standard for 1977 the additional energy consumed will be 2.68 kwh/kkg (2.44 kwh/ton) of iron made. The additional power required for the typical 2,995 kkg/day (3,300 tons/day) blast furnace facility will be 335.7 kw (450 hp). The annual operating cost for this additional consumption of power will be approximately $33,750.00.

3. Non-Water Quality Aspects

    a. Air Pollution: Although the blast furnace exhaust fumes will be passed through a cleaning system and utilized in system heating, pollution of air will still be generated. The problem will arise from "slips" which are caused by arching of the furnace charge. The arch breaks and the burden slips into the void. This causes a rush of gas to the top of the furnace, which develops abnormally high pressures which are greater than the gas-cleaning equipment can handle. Bleeders are then opened to release the pressure which results in a dense cloud of dust being discharged to the atmosphere.

    b. Solid Waste Disposal: There should be no problem in disposing of the solid waste which will be generated. It can be internally consumed in the sinter process plant.

Blast Furnace (Ferromanganese)

1. Base Level of Treatment: Scrubber water on closed recycle system with thickener and vacuum filters for solids dewatering. Gas cooler water once through.

2. Additional Power Requirements: Additional electrically driven equipment will have to be installed to bring the quality of the effluent of the water treatment system used in the fume collection of the ferro-manganese blast furnace iron making process up to the anticipated standard for 1977. The additional energy consumed will be 10.7 kwh/kkg (9.76 kwh/ton) of iron produced. For the typical 744 kkg/day (820 tons/day) ferro-manganese blast furnace, the power required will be 333.5 kw (547 hp). The annual cost for electrical power to operate the new equipment will be $33,525.00.

3. Non-Water Quality Aspects

    a. Air Pollution: The ferro-manganese blast furnace gas is more difficult to clean. In fact, if uncontrolled, this process could be one of the most prolific pollution producers of any of the metallurgical processes.

    b. Solid Waste Disposal: Same as iron making blast furnace (iron).

TABLE 57

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Blast Furnace (Iron)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
. Once-through - solids removed via thickener and vacuum filter. Polymer added to improve settling.	SS CN^- Phenol NH_3 $S^=$ F^- pH	50 2.0 1.0 10 4 5 7-9	Widely used, SS removal efficiency depends upon sludge level & filter schedule.	Removes suspended solids, and a minor portion of volatiles.	12-18 mo.	1/2 acre (100' x 200')	Volatiles lost through surface evaporation	Iron oxide sludge to sinter plant or landfill
. To A, add recycle over cooling tower, discharge blowdown only.	SS CN^- Phenol NH_3 $S^=$ F^- pH	50 15 4 125 6 40 6-9	Used in steel industry. Reliable if properly spared. Sludge level controls solids overflow.	Removes most suspended solids plus much of chemical load, although concentrations increase.	18-24 mo.	3/4 acre (150' x 200')	Water spray & volatiles to atmosphere	Iron oxide sludge to sinter plant

Listed in order of increasing effectiveness

TABLE 57 (Cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

EGORY/SUBCATEGORY: Blast Furnace (Iron)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
To B, add treatment of blowdown via alkaline chlorination; precipitation of fluorides with lime; neutralization, filtration and carbon adsorption.	SS CN^- Phenol NH_3 $S^=$ F^- pH	10 0.25 0.5 10 0.3 20 6-9	Alkaline chlorination used at some plants. Carbon adsorption used in other industries. Treatments subject to equipment failures.	May require batch treatment of blowdown to assure performance. High operating costs.	18-24 mo.	3/4 acre (150' x 200')	Increased demand for chlorine, causing increase in pollution from chlorine production & power supply.	Iron oxide sludge to Sinter Plant. Sludge from neutralization step to landfill.

Listed in order of increasing effectiveness

TABLE 57 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Blast Furnace (Iron) Subcategory

Treatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BATEA C	
Investment	2,030,569	1,476,673	413,033	
Annual Costs:				
Capital	87,314	63,497	17,761	
Depreciation	203,057	147,667	41,303	
Operation & Maintenance	71,070	51,683	14,456	
Carbon Column Rental	-	-	184,900	
Sludge Disposal	97,893	-	320	
Energy & Power	43,500	33,750	8,625	
Chemical	58,500	-	24,589	
TOTAL	561,334	296,597	291,954	

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	3900	3900	125	125	
Ammonia, mg/l	10	10	125	10	
Phenol, mg/l	1.0	1.0	4	0.5	
Cyanide, mg/l	2.0	2.0	15	0.25	
Sulfide, mg/l	20	4.0	6 (1)	0.3	
Suspended solids, mg/l	1600	50	50	10	
Fluoride, mg/l	5	5	40 (1)	20	
pH	7-9	7-9	6-9	6-9	

(1) Value expected for typical treatment plant utilizing BPCTCA treatment technology

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Blast Furnace (Ferromanganese)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
. Once thru gas cooler discharge; closed recycle of Venturi scrubber discharge through thickener, and vacuum filter. Polymer added to aid settling.	mg/l SS 100 Phenol 1.0 CN^- 100 NH_3 200 $S^=$ 120 Mn 16 pH 8-10	Used in this industry. Requires attention to recycle system.	High dissolved solids in recycled water; pick-up of volatiles from scrubber recycled water in gas cooler water.	18-24 mo.	3/4 acre (150' x 200')	Volatiles are lost to atmosphere	Filter cake not reuseable in process. Must go to landfill.
. Closed recycle of Venturi scrubber as in A; separate recycle of gas cooler water over cooling tower, with pH control. Blowdown to sewer, and to makeup for Venturi scrubber recycle system.	SS 100 Phenol 4 CN^- 30 NH_3 200 $S^=$ 30 Mn 16 pH 6-9	Used in the past in this industry. Requires constant attention to separate recycle systems.	High concentrations of dissolved material due to recycling; blowdown loads are reduced, but concentrations are high.	18-24 mo.	1 acre (200' x 200')	Volatiles are lost to atmosphere over the cooling tower.	Filter cake not reuseable in process. Must go to landfill.

Listed in order of increasing effectiveness

TABLE 57 (Fe-Mn) (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

GORY/SUBCATEGORY: Blast Furnace (Ferromanganese)

'reatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
Same as in B, with treat-ent of gas cooler system lowdown via alkaline hlorination ; neutraliza-ion; filtration; and arbon adsorption.	mg/l SS 10 Phenol 0.5 CN^- 0.25 NH_3 10 $S^=$ 0.3 Mn 5 pH 6-9	Part of technology used at some iron making blast furnaces; other systems tested on pilot scale. Requires attention to details. Very good.	High operating costs. May require batch treatment of blowdown to assure performance.	18-24 months	1 acre (200' x 200')	Increased demand for chlorine, causing increase in pollution from chlorine production and power supply.	Additional sludges formed during neutralization.

isted in order of increasing effectiveness

TABLE 57 (FeMn)(Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Blast Furnace (Ferromanganese) Subcategory

eatment or Control Technologies dentified under Item III of the cope of Work:	A	BPCTCA B	BATEA C	
vestment	962,971	1,725,624	320,946	
ıual Costs:				
Capital	41,407	74,202	13,800	
Depreciation	96,297	172,562	32,095	
Operation & Maintenance	33,703	60,396	11,233	
Carbon Column Rental	-	-	432,400	
Sludge Disposal	136,875	10,297	-	
Energy & Power	9,750	33,525	5,325	
Chemical	15,000	1,985	28,537	
TOTAL	333,032	352,967	523,390	

:luent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	7700	5500	250	250	
Ammonia, mg/l	250	200	200	10	
Phenol, mg/l	4.0	1.0	4.0	0.5	
Cyanide, mg/l	100	100	30	0.25	
Sulfide, mg/l	150	120	30 (1)	0.3	
Suspended solids, mg/l	5000	100	100	10	
Manganese, mg/l	800	16	16 (1)	5	
pH	9-12	8-10	6-9	6-9	

(1) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology.

Basic Oxygen Furnace Operation

Semi-Wet Systems

1. Base Level of Treatment: Once through system. Treatment of waste waters via thickening with addition of polymer, and with a vacuum filter for dewatering of solids.

2. Additional Energy Requirements: Additional power will be necessary when bringing the quality of the effluent of the water treatment system utilized in the fume collection of the BOF (semi-wet) steelmaking process up to the anticipated standard for 1977. The additional energy utilized will be 0.34 kwh/kkg (0.28 kwh/ton) of steel produced. For the typical 4,429 kkg/day (4,880 tons/day) BOF facility, the additional power required will be 62.66 kw (84 hp). The annual operating cost for this additional installation will be approximately $6,300.00.

3. Non-Water Quality Aspects

    a. Air Pollution: In the BOF (semi-wet) method of steelmaking, the air pollution problem of primary significance will be suspended particulate matter. Although the furnace exhaust fumes will have been passed through a dust wash, 0.1 pound of particulate emission per 1,000 pounds exhaust gases will be emitted into the atmosphere.

    b. Solid Waste Disposal: The solids waste that will be generated by the fume collection system for the BOF (semi-wet) process of steelmaking should present no problem. It can be internally consumed in the sinter process plant.

Wet Systems

1. Base Level of Treatment: Once through system. Treatment system includes classifier and thickener with vacuum filter for solids dewatering.

2. Additional Energy Requirements: To bring the quality of the effluent of the water treatment system utilized in the fume collection of the BOF (wet) steel manufacturing process up to the anticipated standard for 1977, additional energy will be necessary. The additional energy consumed will be 0.44 kwh/kkg (0.40 kwh/ton) of steel made. The additional power required for the typical 6,888 kkg/day (7,590 tons/day) BOF facility will be 125.3 kw (168 hp). The annual operating cost for this additional consumption of power will be approximately $12,600.00.

3. Non-Water Quality Aspects

TABLE 58

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Basic Oxygen Furnace (Semi-Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
. Thickener with polymer and/or magnetic flocculation "once-through"; overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfill filtrate recycled to thickener.	mg/l SS 50 F^- 20 pH 10-12	Widely used in steel industry. Good system.	Must control surges to system; no reduction of heat load.	15 mo.	1/4 acre (100' x 100')	Air: Particulate 0.1#/1000# exhaust gases	Solids consumed internally or used as landfill.
. Same as Item A except overflow recycled to process spray system thru recycle pump system. No aqueous discharge.	SS 0 F^- 0 pH -	Practiced by many plants in steel industry. Very good.	Requires more attention than once-through systems.	15 mo.	1/4 acre (100' x 100')	Air: Particulate 0.1#/1000# exhaust gases	Solids consumed internally or used as landfill.

Listed in order of increasing effectiveness

TABLE 58 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Basic Oxygen Furnace (Semi-Wet Air Pollution Control Methods) Subcategory

Treatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA-BATEA B		
Investment	$ 533,820	$ 187,540		
Annual Costs:				
Capital	22,954	8,065		
Depreciation	53,382	18,754		
Operation & Maintenance	18,684	6,565		
Sludge Disposal	7,984			
Energy & Power	12,675	5,625		
Chemical	47,906			
TOTAL	$ 163,585	$ 39,009		

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	430	430	0		
Suspended solids, mg/l	250	50	0		
Fluoride, mg/l	22	20	0		
pH	10-12	10-12	-		

TABLE 59

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

ATEGORY/SUBCATEGORY: Basic Oxygen Furnace (Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
Fume Collection System with Boiler Hoods							
A. Aqueous discharge from primary scrubber to classifier to thickener. "Once-thru", overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfilled, filtrate recycled to thickener.	mg/l SS 80 F^- 30 pH 6-9	Widely practiced in industry; good	No reduction of heat load must control surges	18 months	1 acre (200'x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally
B. To A, add magnetic and/or chemical polymer flocculation	SS 40 F^- 30 pH 6-9	Widely practiced in industry; very good	Same as Item A	18 months	1 acre (200'x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally
C. To B, add thickener overflow recycle system with blowdown; neutralization of blowdown stream.	SS 50 F^- 50 pH 6-9	Widely practiced in industry; very good	Dissolved material is concentrated by recycle	18 months	1 acre (200'x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally. Additional sludges from neutralization to landfill.

Listed in order of increasing effectiveness

TABLE 59 (Cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

'EGORY/SUBCATEGORY: Basic Oxygen Furnace (Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
To C, add blowdown reatment via settling with oagulation; lime treatment nd neutralization.	SS F^- pH	25 20 6-9	Used in controlling steel and other industry wastes; excellent.	Lime addition requires care in handling; adds to solids wastes generation problem.	18 mo.	1-1/2 acre (200' x 300')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally; additional sludges to landfill.
To D, add activated lumina treatment; iltration.	SS F^- pH	10 5 6-9	Used in water treatment; excellent	Technology untested on steel plant wastes; requires attention to all preceding steps.	18 months	1-1/2 acre (200'x 300')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally; additional sludges to landfill.

Listed in order of increasing effectiveness

TABLE 59 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

reatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BPCTCA C	BATEA D	E
nvestment	$ 1,308,722	$ 27,058	$ 437,326	$ 363,251	$ 359,630
nnual Costs:					
Capital	56,275	1,163	18,805	15,619	15,465
Depreciation	130,872	2,706	43,732	36,325	35,963
Operation & Maintenance	45,805	947	15,306	12,713	12,587
Sludge Disposal	138,627			1,040	
Energy & Power	30,000	675	11,925	10,575	4,500
Chemical		131,400	1,822	6,197	29
TOTAL	$ 401,579	$136,891	$ 91,590	$ 82,469	$ 68,544

fluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels		BPCTCA	BATEA	
Flow, gal/ton	600	600	600	50	50	50
Suspended solids, mg/l	2,000	80	40	50	25	10
Fluoride, mg/l	30	30	30	50 (1)	20	5
pH	6-9	6-9	6-9	6-9	6-9	6-9

(1) Value that can be obtained utilizing BPCTCA treatment technology

a. Air Pollution: The air pollution problem of primary significance in the BOF (wet) method of steelmaking will be particulate emissions. Although the furnace exhaust fumes will be passed through a dust removing both, 0.1 kg of suspended particulate matter per kkg (lb/1,000 lb) of exhaust gases will be emitted into the atmosphere.

b. Solid Waste Disposal: There should be no problem in disposing of the solid waste generated by the fume collection system for the BOF (wet) process for the manufacture of steel. It can be internally consumed in the sinter process plant.

Open Hearth Furnace Operation

1. Base Level of Treatment: Once through system. Water treatment system includes a classifier and thickener with a vacuum filter for solids dewatering.

2. Additional Energy Requirements: Additional power will be necessary when bringing the quality of the effluent of the water treatment system utilized in the fume collection of the open hearth steelmaking process up to the anticipated standard for 1977. The additional energy utilized will be 0.45 kwh/kkg (0.41 kwh/ton) of steel produced. For the typical 6,716 kkg/day (7,400 tons/day) open hearth facility, the additional power required will be 126 kw (169 hp). The annual operating cost for this additional installation will be approximately $12,000.00.

3. Non-Water Quality Aspects

   a. Air Pollution: In open hearth steel manufacturing, the air pollution problem of primary significance will be suspended particulate matter. Although the furnace exhaust fumes will have been passed through a dust wash, 0.1 kkg of particulate emission per kkg(lb/1,000 lb) exhaust gases will be emitted into the atmosphere.

   b. Solid Waste Disposal: The solid waste that will be generated by the fume collection system for the open hearth process of steelmaking should present no problem. It can be internally consumed in the sinter process plant.

Electric Arc Furnace Operation

Semi-Wet Systems

1. Base Level of Treatment: Complete recycle system. Water treatment system includes a classifier and thickener with poly addition and vacuum filter for solids dewatering.

TABLE 60

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

ATEGORY/SUBCATEGORY: Open Hearth

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
A. Aqueous discharge from primary quencher to classifier to thickener, "once through" overflow to sewer underflow through vacuum filters, filter cake recycled to sinter plant or landfilled. Filtrate returned to thickener.	mg/l S.S. 80 F^- 20 NO_3^- 35 Zn 220 pH 3-7	Currently used in steel industry; fair	No reduction of heat load; must control surges.	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gasses	Solid Waste consumed internally
B. Same as Item (A) but with thickener magnetic and/or chemical flocculation	S.S. 50 F^- 20 NO_3^- 35 Zn 200 pH 3-7	Currently used in steel industry; good.	No reduction of heat load must control surges; polymer feed must be maintained	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gasses	Solid Waste consumed internally

* Listed in order of increasing effectiveness

TABLE 60 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Open Hearth

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
. Same as Item (B) except thickener overflow recycled to scrubber system with blowdown. A lime addition to recycled water is required from a process standpoint.	S.S. F^- NO_3 Zn pH	50 100 150 25 6-9	Widely used in industry; good	No reduction of heat load; must control surges pH chemical feed must be maintained.	18 months	1 acre (200'x200')	Air: Particulate 0.1#/1000# exhaust gases	Solid Waste consumed internally or disposed to landfill.
		mg/l						
. Same as Item (C) except blowdown treated through lime precipitation of fluoride and zinc; neutralization, sedimentation, and denitrification.	SS F^- NO_3 Zn pH	25 20 45 5 6-9	Used in water treatment & chemical industries. Needs testing on steel wastes. Very good	No reduction of heat load; must control surges. pH chemical feed must be maintained. High volume of solids formed	18 months	1-1/2 acres (200'x300')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally or disposed to landfill
. Same as Item (D) with additional blowdown treatment using activated alumina and filtration.	SS F^- NO_3 Zn pH	10 5 45 3 6-9	Same as Item (D)	Same as Item (D)	18 months	2 acres (200'x 400')	Air: Particulate 0.1#/1000# exhaust gases	Solid waste consumed internally or disposed to landfill

Listed in order of increasing effectiveness

TABLE 60 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Open Hearth Furnace Subcategory

eatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BPCTCA C	BATEA D	E
vestment	$ 892,416	$ 27,203	$ 505,700	$ 1,567,347	$ 468,82
ual Costs:					
Capital	38,373	1,170	21,745	67,395	20,16
Depreciation	89,242	2,720	50,570	156,735	46,88
Operation & Maintenance	31,235	952	17,700	54,857	16,40
Sludge Disposal	40,515			4	
Energy & Power	12,750	675	12,000	12,000	7,50
Chemical		40,500	1,140	17,872	2
OTAL	$ 212,115	$ 46,017	$ 103,155	$ 308,863	$ 90,97

luent Quality:

ffluent Constituents arameters - units	Raw Waste Load	Resulting Effluent Levels		BPCTCA		
ow, gal/ton	600	600	600	50	50	50
spended solids, mg/l	2,000	80	50	50	25	10
uoride, mg/l (1)	20	20	20	100 (2)	20	5
trate, mg/l (1)	35	35	35	150 (2)	45	45
nc, mg/l (1)	400	220	200	25 (2)	5	3
	3-7	3-7	3-7	6-9	6-9	6-9

)A wide range in fluoride, nitrate, and zinc levels are found depending on types of of raw materials used, fuels, and other operating conditions.

)Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

2. Additional Energy Requirements: No additional power will be necessary when bringing the quality of the effluent from the water treatment system utilized in the fume collection of the electric furnace (semi-wet) steelmaking process up to the anticipated standard for 1977.

3. Non-Water Quality Aspects

   a. Air Pollution: In the electric furnace (semi-wet) method of steelmaking, the air pollution problem of primary significance will be suspended particulate matter. Although the furnace exhaust fumes will have been scrubbed, 0.1 kkg of particulate emission per kkg(lb/ lb) of exhaust gases will be emitted into the atmosphere.

   b. Solid Waste Disposal: The solid waste that will be generated by the fume collection system for the electric furnace (semi-wet) process of steelmaking should present no problem. It can be internally consumed in the sinter process plant.

Wet Systems

1. Base Level of Treatment: Once through system. The water treatment system is comprised of a classifier, thickener, and vacuum filter for dewatering of solids.

2. Additional Power Requirements: To bring the quality of the effluent of the water treatment system utilized in the fume collection of the electric furnace (wet) steel manufacturing process up to the EPA standard for 1977, additional energy will be necessary. The additional energy consumed will be 0.92 kwh/kkg (0.83 kwh/ton) of steel made. The additional power required for the typical 1,652 kkg/day (1,820 tons/day) facility of this type will be 63 kw (84 hp). The annual operating cost for this additional consumption of power will be approximately $6,300.00.

3. Non-Water Quality Aspects

   a. Air Pollution: The air pollution problem of primary significance in the electric furnace (wet) method of steelmaking will be particulate emissions. Although the furnace exhaust fumes will be passed through a dust removing bath, 0.1 kg of suspended particulate matter per kkg(lb/1,000 lb) of exhaust gases will be emitted into the atmosphere.

   b. Solid Waste Disposal: There should be no problem in disposing of the solid waste generated by the fume collection system for the electric furnace (wet) process for the manufacture of steel. It can be internally consumed in the sinter process plant.

TABLE 61

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Electric Arc Furnace (Semi-Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
. Discharge from spark box or flame trap to classifier to thickener; overflow recycled to spark box or flame trap; underflow through vacuum filters, filtrate returns to thickener; sludge to sinter or landfill.	mg/l SS 0 F^- 0 pH -	Currently practiced by steel plants of this type. Excellent	No reduction of heat load. Spray system requires much maintenance.	12 months	1/8 acre (50' x 100')	Air: Particulate 0.1#/1000# exhaust gases	Solids consumed internally or used as landfill.

Listed in order of increasing effectiveness

TABLE 61 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Electric Arc Furnace (Semi-wet Air Pollution Methods) Subcategory

Treatment or Control Technologies Identified under Item III of the Scope of Work:	BPCTCA BATEA			
Investment	$ 615,825			
Annual Costs:				
Capital	26,481			
Depreciation	61,582			
Operation & Maintenance	21,554			
Energy & Power	17,550			
Sludge Disposal	7,446			
Chemical	1,500			
TOTAL	$ 136,113			

Effluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	100	0			
Suspended solids,mg/l	2,000	0			
Fluoride, mg/l	25	0			
pH	6-9	-			

TABLE 62

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

ATEGORY/SUBCATEGORY: Electric Arc Furnace (Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
A. Aqueous discharge from scrubber & separator thru classifier to a thickener. "Once-thru" thickener overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfilled, filtrate recycled to thickener.	SS F^- Zn pH	100 20 16 6-9	Used in steel industry; good. Minimum maintenance and downtime.	No reduction of heat load. Must control surges. Most EAF plants have no sinter plants nearby.	18 months	1 acre (200' x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid wastes consumed internally or used as landfill.
B. Same as Item (A) but with thickener magnetic and/or chemical polymer flocculation.	SS F^- Zn pH	50 20 16 6-9	Used in steel industry; good.	Same as Item (A)	18 months	1 acre (200' x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid wastes consumed internally or used as landfill.

Listed in order of increasing effectiveness

TABLE 62 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

ATEGORY/SUBCATEGORY: Electric Arc Furnace (Wet)

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/1						
C. Same as Item B except thickener overflow recycled to scrubber system with blowdown.	SS F^- Zn pH	50 75 10 6-9	Widely used in steel industry. Very good.	Same as Item (A)	18 months	1 acre (200'x 200')	Air: Particulate 0.1#/1000# exhaust gases	Solid wastes consumed internally or used as landfill.
D. Same as Item C except blowdown treated with lime addition, neutralization, and sedimentation.	SS F^- Zn pH	25 20 5 6-9	Currently in use by some plants in other industries; technically transferable. Excellent.	Same as Item (A)	18 months	1-1/2 acre (200' x 300')	Air: Particulate 0.1#/1000# exhaust gases	Solid wastes consumed internally or used as landfill.
E. Same as Item D, except additional treatment of blowdown with activated alumina and pressure filtration.	SS F^- Zn pH	10 5 3 6-9	Used in water treatment industry; technically transferable. Excellent.	Same as Item (A)	18 months	1-1/2 acre (200'·x 300")	Air: Particulate 0.1#/100# exhaust gases	Solid wastes consumed internally or used as landfill.

* Listed in order of increasing effectiveness

TABLE 62 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

atment or Control Technologies entified under Item III of the ope of Work:	A	BPCTCA B	BPCTCA C	BATEA D	E
estment	$ 493,740	$ 27,203	$ 194,820	$ 286,148	$ 230,025
ıal Costs:					
apital	21,231	1,170	8,377	12,304	9,890
epreciation	49,374	2,720	19,482	28,615	23,003
peration & Maintenance	17,280	952	6,819	10,015	8,050
ıergy & Power	12,450	675	5,625	7,500	1,500
ludge Disposal	11,716			416	
ıemical		4,200		720	7
)TAL	$ 112,051	$ 9,717	$ 40,303	$ 59,570	$ 42,450

.uent Quality:

:fluent Constituents .rameters - units	Raw Waste Load	Resulting Effluent Levels		BPCTCA	BATEA	
ow, gal/ton	240	240	240	50	50	50
spended solids, mg/l	3,500	100	50	50	25	10
uoride, mg/l	20	20	20	75 (1)	20	5
ıc, mg/l	20	16	16	10 (1)	5	3
	6-9	6-9	6-9	6-9	6-9	6-9

) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

Vacuum Degassing

1. Base Level of Treatment: Once through system. Treatment involves a scale removal classifier.

2. Additional Energy Requirements: Additional power will be necessary when bringing the quality of the effluent from the water treatment system utilized in the barometric condensers for the vacuum degassing process up to the anticipated standard for 1977. The additional energy utilized will be 11.4 kwh/kkg (10.3 kwh per ton) of steel produced. For the typical 472 kkg/day (520 tons/day) vacuum degassing facility, the additional power required will be 224 kw (300 hp). The annual operating cost for this additional power consumption will be approximately $22,500.00.

3. Non-Water Quality Aspects

   a. Air Pollution: Non-condensable gases are vented to the atmosphere during degassing.

   b. Solid Waste Disposal: The solid waste that will be generated by the creation of a vacuum for the degassing process should present no problem. It can be internally consumed in the sinter process plant.

Continuous Casting

1. Base Level of Treatment: Recycle system utilizing scale pit settling, oil skimming, flat bed filtration and cooling towers.

2. Additional Energy Requirements: Additional power will not be required to meet proposed standards for 1977 since the base level is the BPCTCA treatment model.

3. Non-Water Quality Aspects

   a. Air Pollution: Non-condensable gases and fumes are generated during continuous casting operations but to a relatively minor extent.

   b. Solid Waste Disposal: The solid waste generated can be consumed internally in the sinter plant.

Advanced Technology, Energy and Nonwater Impact

The energy requirements and nonwater quality aspects associated with the advanced treatment technology for each subcategory are discussed below.

By Product Coke

TABLE 63

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

'EGORY/SUBCATEGORY: Vacuum Degassing

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
. Scale sump or settling basin for solids removal. "Once-through"- overflow to sewer. Solids recycled to Sinter plant.	SS Pb Mn NO_3^- Zn pH	100 2.5 15 80 20 6-9	Used in steel industry.	Surges must be controlled. No reduction in heat load.	18 months	1 acre (200'x200')	Gases pass off to atmosphere	Solids consumed internally
. Same as Item (A) except overflow recycled via cooling tower to degassing unit with blowdown to sewer.	SS Pb Mn NO_3^- Zn pH	50 2.0 10 175 15 6-9	Used in steel industry.	Surges must be controlled. No reduction in heat load.	18 months	1 acre (200'x 200')	Gases pass off to atmosphere	Solids consumed internally.
. Same as Item (B) except blowdown is treated by lime addition; coagulation/ flocculation; anaerobic denitrification; neutralization; and final clarification.	SS Pb Mn NO_3^- Zn pH	25 0.5 5 45 5 6-9	Some treatment methods used in this and related industries. Denitrification is not necessary where N_2 is not used in the process. Very good.	Surges must be controlled. No reduction in heat load. Denitrification untested on steel plant wastes.	18 months	1/2 acre (100' x 200'	Gases pass off to atmosphere	Solids consumed internally. Additional solids from lime treatment to landfill.

Listed in order of increasing effectiveness

TABLE 63 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

EGORY/SUBCATEGORY: Vacuum Degassing

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents		Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
		mg/l						
. Same as Item (C) except for final treatment of blowdown via pressure filtration.	SS	10	Used in steel industry. Very good.	Surges must be controlled. No reduction in heat load.	18 months	1/4 acre (100' x 100')	Gases pass off to atmosphere	Solids consumed internally. Additional solids to landfill.
	Pb	0.3						
	Mn	3						
	NO_3^-	45						
	Zn	3						
	pH	6-9						

.isted in order of increasing effectiveness

TABLE 63 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Vacuum Degassing Subcategory

reatment or Control Technologies Identified under Item III of the Scope of Work:	A	BPCTCA B	BATEA C	D
ıvestment	$ 259,774	$ 423,797	$ 307,170	$ 60,008
ınual Costs:				
Capital	11,170	18,224	13,208	2,581
Depreciation	25,977	42,379	30,717	6,000
Operation & Maintenance	9,092	14,832	10,750	2,100
Sludge Disposal	36		31	
Energy & Power		22,500	29,250	2,250
Chemical			753	
TOTAL	$ 46,275	$ 97,935	$ 84,709	$ 12,931

'fluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	560	560	25	25	25
Suspended solids, mg/l	200	100	50	25	10
Lead, mg/l	3.0	2.5	2.0 (3)	0.5	0.3
Manganese, mg/l	20	15	10 (3)	5	3
Nitrate, mg/l (1)	80	80	175 (3)	45	45
Zinc, mg/l (2)	30	20	15 (3)	5	3
pH	5-10	6-9	6-9 (3)	6-9	6-9

(1) If nitrogen gas is used to purge system, nitrate concentrations can be very high. If inert gases are used, nitrates are negligible

(2) Zinc concentration depends on type of scrap used in steelmaking process

(3) Value expected of typical treatment plant utilizing BPCTCA technology

TABLE 64

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

TEGORY/SUBCATEGORY: Continuous Casting

Treatment and/or Control Methods Employed*	Resulting Effluent Levels for Critical Constituents (mg/l)	Status and Reliability	Problems and Limitations	Implementation Time	Land Requirements	Environmental Impact Other Than Water	Solid Waste Generation and Primary Constituents
. Recycle system with scale pit; overflow recycled via flat bed filter to cooling tower to caster spray system with blowdown to sewer. Oil skimming at scale pit surface.	SS 50 O & G 15 pH 6-9	Used in this industry. Good. Scale and oil removal facilities must be maintained.	No reduction in heat load. Pit must be kept clean to prevent solids build up and washover.	12 mo.	1/8 acre (50'x 100')	None	Solids consumed internally. Oil sold for re-processing or incinerated.
. Same as Item A except blowdown treatment by pressure filtration.	SS 10 O & G 10 pH 6-9	Widely used in this industry. Excellent. Scale and oil removal facilities must be maintained.	No reduction in heat load Pit must be kept clean to prevent solids build up and washover.	15 mo.	1/4 acre (100' x 100')	None	Solids consumed internally. Additional solids to landfill.

Listed in order of increasing effectiveness

TABLE 64 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Continuous Casting Subcategory

:eatment or Control Technologies :dentified under Item III of the ;cope of Work:	BPCTCA A	BATEA B		
,vestment	1,980,816	99,170		
,nual Costs:				
Capital	85,175	4,264		
Depreciation	198,081	9,917		
Operation & Maintenance	69,328	3,470		
Sludge Disposal	730	-		
Energy & Power	36,975	9,000		
TOTAL	390,289	26,651		

fluent Quality:

Effluent Constituents Parameters - units	Raw Waste Load	Resulting Effluent Levels			
Flow, gal/ton	4200	125	125		
Oil & grease, mg/l	30	15	10		
Suspended solids, mg/l	50	50	10		
pH	6-9	6-9	6-9		

1. Additional energy requirements:

   a. Treatment Alternative I:

   To improve the quality of the waste water treatment systems effluent from the anticipated 1977 standard to the anticipated 1983 standard, additional power consuming equipment is necessary. The additional power requirements will be 373 kw (500 hp) for the typical 2,414 kkg/day (2,660 ton/day) by-product coke making facility. The annual operating cost for this additional equipment will be $37,500.00.

   b. Treatment Alternative II:

   Additional power will be necessary to improve the effluent water discharges to meet anticipated 1983 standards. The additional power consumption will be 2.02 kwh/kkg (1.83 kwh/ton) of steel produced. The additional power requirements will be 223.8 kw (300 hp) for the typical 2,424 kkg/day (2,600 ton/day) by-product coke making facility. The annual operating cost due to this additional equipment will be $22,500.00.

2. Non-Water Quality Aspects (Both Alternates):

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

<u>Coke Making-Beehive Operation</u>

1. Additional Energy Requirements: No additional power will be required to comply with the anticipated 1983 EPA standard.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

<u>Sintering</u>

1. Additional Power Requirements: To improve the quality of the waste water treatment system effluent from the anticipated 1977 standard to the anticipated 1983 standard, additions will have to be made to the system. The additional energy consumption will be 1.31 kwh/kkg (1.18 kwh/ton) of sinter produced. For the typical 2,704 kkg/day (2,980 tons/day) facility 147 kw (197 hp) will have to be added to the system. The operating cost for this 147 kw (197 hp) will be $14,755.00 per year.

2. Non-Water Quality Aspects

a. Air Pollution: Same as 1977

b. Solid Waste Disposal: Same as 1977

Blast Furnace (Iron)

1. Additional Power Requirements: To bring the quality of the effluent of the waste water treatment system used in the dust cleaning of the blast furnace (iron) making process from the anticipated standard for 1977 to the anticipated standard for 1983, requires additional electrical powered equipment. The additional energy consumption will be 0.68 kwh/kkg (.62 kwh/ton) of iron produced. For the typical 2,995 kkg/day (3,300 tons/day) blast furnace facility, the additional power required will be 85.8 kw (115 hp). The annual operating cost for the additional equipment will be approximately $8,625.00.

2. Non-water Quality Aspects

    a. Air Pollution: Same as 1977

    b. Solid Waste Disposal: Same as 1977

Blast Furnace (Ferromanganese)

1. Additional Power Requirements: Additional electrically powered equipment will have to be added to the 1977 system to improve the waste water treatment system effluent to meet the anticipated standard for 1983. The additional energy consumed will be 1.71 kwh/kkg (1.55 kwh/ton) of iron produced. For the average 744 kkg/day (820 tons/day) facility, equipment driven by 53 kw (71 hp) comprised the addition to the facility. The additional operating cost will be approximately $5,325.00 per year.

2. Non-Water Quality Aspects

    a. Air Pollution: Same as 1977

    b. Solid Waste Disposal: Same as 1977

Basic Oxygen Furnace Operation

Semi-Wet Systems

1. Additional Power Requirements: No additional power will be necessary to bring the water quality to meet the anticipated 1983 standard.

2. Non-Water Quality Aspects:

a. Air Pollution: Same as 1977

b. Solid Waste Disposal: Same as 1977

Wet Systems

1. Additional Power Requirements: Additional equipment will be required to improve the waste water system to the anticipated 1983 standard. The additional energy consumption will be 0.15 kwh/kkg (.14 kwh/ton) of steel produced. For the typical 6,888 kkg/day (7,590 tons/day) BOF wet facility, the additional power required will be 105 kw (141 hp). The annual operating cost for the consumption of this extra power will be approximately $10,575.00.

2. Non-Water Quality Aspects

   a. Air Pollution: The additional waste water equipment required will not affect the quality of the exhaust gases released to the atmosphere. The particulate emissions will be the same as they were for 1977.

   b. Solid Waste Disposal: Same as 1977

Open Hearth Furnace

1. Additional Power Requirements: Additional equipment will be required to improve the quality of the wastewater treatment system utilized in the fume collection of the open hearth steel manufacturing process to the anticipated standard for 1983. The additional energy consumption will be 0.45 kwh/kkg (0.39 kwh/ton) of steel produced. For the typical 6,716 kkg/day (7,400 tons/day) open hearth facility, the additional power required will be 119 kw (160 hp). The annual operating cost for the consumption of this added power will be approximately $12,000.00.

2. Non-Water Quality Aspects

   a. Air Pollution: The additional waste water equipment required will not affect the quality of the exhaust gases released to the atmosphere. The particulate emissions will be the same as they were for 1977.

   b. Solid Waste Disposal: Same as 1977.

Electric Arc Furnaces

Semi-Wet Systems

1. Additional Power Requirements: No additional power requirements over 1977.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

Wet Systems

1. Additional Power Requirements: Additional equipment will be required to improve the quality of the effluent of the waste water treatment system utilized in the fume collection of the electric furnace (wet) steel manufacturing process to meet the anticipated standard for 1983. The additional energy consumption will be 0.98 kwh/kkg (0.89 kwh/ton) of steel produced. For the typical 1,652 kkg/day (1,820 tons/day) electric furnace (wet) facility, the additional power required will be 75 kw (100 hp). The annual operating cost for the consumption of this extra power will be approximately $7,500.00.

2. Non-Water Quality Aspects

   a. Air Pollution: The additional equipment required will not affect the quality of the exhaust gases released to the atmosphere. The particulate emissions will be the same as they were at 1977.

   b. Solid Waste Disposal: Same as 1977

Vacuum Degassing

1. Additional Power Requirements: To improve the quality of the waste water treatment system effluent to the anticipated 1983 standard, will require additional equipment. The additional power requirement is 291 kw (390 hp). This equates to 15.9 kwh/kkg (14.4 kwh/ton) of steel produced. The cost to operate this additional equipment will be $29,250.00.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

Continuous Casting Operation

1. Additional Power Requirements: Additional equipment will be required to improve the water to meet the anticipated 1983 standard. The additional energy consumption will be 2.2 kwh/kkg (2.0 kwh/ton) of steel produced. The additonal power requirements will be 89.5 kw (120 hp) for the typical 971 kkg/day (1070 ton/day) continuous

casting facility. The annual operating cost due to the addition of this equipment will be $9,000.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

Full Range of Technology in Use or Available to the Steel Industry

The full range of technology in use or available to the steel industry today is presented in Tables 54 to 64. In addition to presenting the range of treatment methods available, these tables also describe for each method:

1. Resulting effluent levels for critical constituents

2. Status and reliability

3. Problems and limitations

4. Implementation time

5. Land requirements

6. Environmental impacts other than water

7. Solid waste generation

Basis of Cost Estimates

Costs associated with the full range of treatment technology including investment, capital depreciation, operating and maintenance, and energy and power are presented on water effluent cost tables corresponding to the appropriate category technology Tables 54 to 64.

Costs were developed as follows:

1. National annual production rate data was collected and tabulated along with the number of plants in each subcategory. From this, an "average" size plant was established.

2. Flow rates were established based on the data accumulated during the survey portion of this study and from knowledge of what flow reductions could be obtained with minor modifications. The flow is here expressed in l/kkg or gal/ton of product.

3. Then a treatment process model and flow diagram was developed for each subcategory.

This was based on knowledge of how most industries in a certain subcategory handle their wastes, and on the flow rates established by 1 and 2 above.

4. Finally, a quasi-detailed cost estimate was made on the developed flow diagram.

Total annual costs in August, 1971 dollars were calculated on total operating costs (including all chemicals, maintenance, labor, energy and power) and the capital recovery costs. Capital recovery costs were then subdivided into straight-line ten-year depreciation and the cost of capital at a seven percent annual interest rate for ten years.

The capital recovery factor (CFR) is normally used in industry to help allocate the initial investment and the interest to the total operating cost of a facility. The CFR is equal to i plus i divided by a-1, where a is equal to 1 + i to the power n. The CFR is multiplied by the initial investment to obtain the annual capital recovery. That is: (CFR) (P) = ACR. The annual depreciation is found by dividing the initial investment by the depreciation period (n = 10 years). That is, P/10 = annual depreciation. Then the annual cost of capital has been assumed to be the total annual capital recovery minus the annual depreciation. That is, ACR - P/10 = annual cost of capital.

Construction costs are dependent upon many different variable conditions and in order to determine definitive costs the following parameters are established as the basis of estimates. In addition, the cost estimates as developed reflect only average costs.

a. The treatment facilities are contained within a "battery limit" site location and are erected on a "green field" site. Site clearance costs such as existing plant equipment relocation, etc., are not included in cost estimates.

b. Equipment costs are based on specific effluent water rates. A change in water flow rates will affect costs.

c. The treatment facilities are located in close proximity to the steelmaking process area. Piping and other utility costs for interconnecting utility runs between the treatment facilities battery limits and process equipment areas are not included in cost estimates.

d. Sales and use taxes or freight charges are not included in cost estimates.

e. Land acquisition costs are not included in cost estimates.

f. Expansion of existing supporting utilities such as sewage, river water pumping stations, increased boiler capacity are not included in cost estimates.

g. Potable water, fire lines and sewage lines to service treatment facilities are not included in cost estimates.

h. Limited instrumentation has been included for pH and fluoride control, but no automatic samplers, temperature indicators, flow meters, recorders, etc., are included in cost estimates.

j. The site conditions are based on:

   1. No hardpan or rock excavation, blasting, etc.
   2. No pilings or spread footing foundations for poor soil conditions.
   3. No well pointing.
   4. No dams, channels, or site drainage required.
   5. No cut and fill or grading of site.
   6. No seeding or planting of grasses and only minor site grubbing and small shrubs clearance; no tree removal.

k. Controls buildings are prefabricated buildings, not brick or block type.

l. No painting, pipe insulation, and steam or electric heat tracing are included.

m. No special guardrails, buildings, lab test facilities, signs, docks are included.

Other factors that affect costs but cannot be evaluated:

a. Geographic location in United States.

b. Metropolitan or rural areas.

c. Labor rates, local union rules, regulations, and restrictions.

d. Manpower requirements.

e. Type of contract.

f. Weather conditions or season

g. Transportation of men, materials, and equipment.

h. Building code requirements.

j. Safety requirements.

k. General business conditions.

The cost estimates do reflect an on-site "Battery Limit" treatment plant with electrical sub-station and equipment for powering the facilities, all necessary pumps, treatment plant interconnecting feed pipe lines, chemical treatment facilities, foundations, structural steel, and control house. Access roadways within battery limits area are included in estimates based upon 3.65 cm (1.5 inch) thick bituminous wearing course and 10 cm (4 inch) thick sub-base with sealer, binder, and gravel surfacing. A 9 gage chain link fence with three strand barb wire and one truck gate was included for fencing in treatment facilities area.

The cost estimates also include a 15% contingency, 10% contractor's overhead and profit, and engineering fees of 15%.

SECTION IX

EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

EFFLUENT LIMITATIONS GUIDELINES

Introduction

The effluent limitations which must be achieved July 1, 1977 are to specify the effluent quality attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of the best existing performance by plants of various sizes, ages and unit processes within the industrial subcategory. This average is not based upon a broad range of plants within the steel industry, but based upon performance levels achieved by plants purported by the industry or by regulatory agencies to be equipped with the best treatment facilities. Experience demonstrated that in some instances these facilities were exemplary only in the control of a portion of the waste parameters present. In those industrial categories where present control and treatment practices are uniformly inadequate, a higher level of control than any currently in place may be required if the technology to achieve such higher level can be practicably applied by July 1, 1977.

Considerations must also be given to:

a. the size and age of equipment and facilities involved:

b. the processes employed:

c. non-water quality environmental impact (including energy requirements):

d. the engineering aspects of the application of various types of control techniques:

e. process changes:

f. the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application:

Also, Best Practicable Control Technology Currently Available emphasizes treatment facilities at the end of a manufacturing process but includes the control technologies within the process itself when the latter are considered to be normal practice within an industry.

A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available." As a result of demonstration projects, pilot plants and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

Rationale for Selection of BPCTCA

The following paragraph summarized factors that were considered in selecting the categorization, water use rates, level of treatment technology, effluent concentrations attainable by the technology and hence the establishment of the effluent limitations for BPCTCA.

Size and Age of Facilities and Land Availability Considerations:

As discussed in Section IV, the age and size of steel industry facilities has little direct bearing on the quantity or quality of wastewater generated. Thus, the ELG for a given subcategory of waste source applies equally to all plants regardless of size or age. Land availability for installation of add-on treatment facilities can influence the type of technology utilized to meet the ELG's. This is one of the considerations which can account for a range in the costs that might be incurred.

Consideration of Processes Employed:

All plants in a given subcategory use the same or similar production methods, giving similar discharges. There is no evidence that operation of any current process or subprocess will substantially affect capabilities to implement the best practicable control technology currently available. At such time that new processes, such as direct reduction, appear imminent for broad application the ELG's should be amended to cover these new sources. No changes in process employed are envisioned as necessary for implementation of this technology for plants in any subcategory. The treatment technologies to achieve BPCTCA are end of process methods which can be added onto the existing treatment facilities.

Consideration of Nonwater Quality Environmental Impact:

Impact of Proposed Limitations on Air Quanity:

The increased use of recycle systems and stripping columns have the potential for increasing the loss of volatile substances to the atmosphere. Recycle systems are so effective in reducing waste water volumes and hence waste loads to and from treatment systems and in reducing the size and cost of treatment systems that a tradeoff must be accepted. Recycle systems requiring the use of cooling towers have contributed significantly to reductions of effluent loads while contributing only minimally to air pollution problems. Stripper vapors have been successfully recovered as usable byproducts or can be routed to incinerators. Careful operation of either system can avoid or minimize air pollution problems.

Impact of Proposed Limitations on Solid Waste Problems:

Consideration has also been given to the solid waste aspects of water pollution controls. The processes for treating the waste waters from this industry produce considerable volumes of sludges. Much of this material is inert iron oxide which can be reused profitably. Other sludges not suitable for reuse must be disposed of to landfills since most of it is chemical precipitates which could be little reduced by incineration. Being precipitates, they are by nature relatively insoluble and non- hazardous substances requiring minimal custodial care.

In order to ensure long-term protection of the environment from harmful constituents, special consideration of disposal sites should be made. All landfill sites should be selected so as to prevent horizontal and vertical migration of these contaminants to ground or surface waters. In cases where geologic conditions may not reasonably ensure this, adequate mechanical precuations (e.g., impervious liners) should be taken to ensure long-term protection to the environment. A program of routine periodic sampling and analysis of leachates is advisable. Where appropriate the location of solid hazardous materials disposal sites, if any, should be permanently recorded in the appropriate office of legal jurisdication.

Impact of Proposed Limitations on Energy Requirements:

The effects of water pollution control measures on energy requirements has also been determined. The additional energy required in the form of electric power to achieve the effluent limitations proposed for BPCTCA and BATEA amounts to less than 1.5% of the 51.6 billion kwh of electrical energy used by the steel industry in 1972.

The enhancement to water quality management provided by these proposed effluent limitations substantially outwieghs the impact on air, solid waste, and energy requirements.

Consideration of the Engineering Aspects of the Application of Various Types of Control Techniques:

The level of technology selected as the basis for BPCTCA limitations is considered to be practicable in that the concepts are proven and are currently available for implementation and may be readily applied as "add-ons" to existing treatment facilities.

Consideration of Process Changes:

No in-process changes will be required to achieve the BPCTCA limitations although recycle water quality changes may occur as a result of efforts to reduce effluent discharge rates. Many plants are employing recycle, cascade uses, or treatment and recycle as a means to minimizing water use and the volume of effluents discharged. The limitations are load limitations (unit weight of pollutant discharged per unit weight of product) only and not volume or concentration limitations. The limitations can be achieved by extensive treatment of large flows, however, an evaluation of costs indicates that the limitations can usually be achieved most economically by minimizing effluent volumes.

Consideration of Costs versus Effluent Reduction Benefits:

In consideration of the costs of implementing the BPCTCA limitations relative to the benefits to be derived, the limitations were set at values which would not result in excessive capital or operating costs to the industry.

To accomplish this economic evaluation, it was necessary to establish the treatment technologies that could be applied to each subcategory in an add-on fashion, the effluent qualities attainable with each technology, and the costs. In order to determine the added costs, it was necessary to determine what treatment processes were already in place and currently being utilized by most of the plants. This was established as the base level of treatment.

Treatment systems were then envisioned which, as add-ons to existing facilities, would achieve significant waste load reductions. Capital and operating costs for these systems were then developed for the average size facility. The average size was determined by dividing the total industry production by the number of operating facilities. The capital costs were developed from a quasi-detailed engineering estimate of the cost of the components of each of the systems. The annual operating cost for each of the facilities was determined by summing the capital recovery (basis ton year straight line depreciation) and capital use (basis 7% interest) charges, operating and maintenance costs, chemical costs, and utility costs.

Cost effectiveness diagrams were then prepared to show the pollution reduction benefits derived relative to the costs incurred. As expected, the diagrams show an increasing cost for treatment per percent reduction obtained as the percent of the initial pollutional load remaining decreased. The BPCTCA limitations were set at the point where the costs per percent pollutant reduction took a sharp break upward toward higher costs per percent of pollutant removed. These cost effectiveness diagrams are presented in Section X.

The initial capital investment and annual expenditures required of the industry to achieve BPCTCA were developed by multiplying the costs (capital or annual) for the average size facility by the number of facilities operating for each subcategory. These costs are summarized in Table 89 in Section X.

After selection was made of the treatment technology to be designated as one means to achieve the BPCTCA limitations for each subcategory, a sketch of each treatment model was prepared. The sketch for each subcategory is presented following the table presenting the BPCTCA limitations for the subcategory.

Identification of Best Practicable Control Technology Currently Available - BPCTCA

Based on the information contained in Sections III through VIII of this report, a determination has been made that the quality of effluent attainable through the application of the Best Practicable Control Technology Currently Available is as listed in Tables 65 through 76. These tables set forth the ELG's for the following subcategories of the steel industry:

I	By Product Coke Subcategory
II	Beehive Coke Subcategory
III	Sintering Subcategory
IV	Blast Furnace (Iron) Subcategory
V	Blast Furnace (Ferromanganese) Subcategory
VI	Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory
VII	Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory
VIII	Open Hearth Furnace Subcategory
IX	Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory
X	Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory
XI	Vacuum Degassing Subcategory
XII	Continuous Casting Subcategory

ELG's have not been set for Pelletizing and Briquetting Operations because plants of this type were not found to be operating as an integral part of any steel mill. These operations will be considered in mining regulations to be proposed at a later date since they are normally operated in conjunction with mining operations.

In establishing the subject guidelines, it should be noted that the resulting limitations or standards are applicable to aqueous waste discharge only, exclusive of non-contact cooling waters. In the section of this report which discusses control and treatment technology for the iron and steelmaking industry as a whole, a qualitative reference has been given regarding "the environmental impact other than water" for the subcategories investigated.

The effluent guidelines established herein take into account only those aqueous consitituents considered to be major pollutants in each of the subcategories investigated. In general, the critical parameters were selected for each subcategory on the basis of those waste constituents known to be generated in the specific manufacturing process and also known to be present in sufficient quantity to be inimical to the environment. Certain general parameters such as suspended solids naturally include the oxides of iron and silica, however, these latter specific constituents were not included as critical parameters, since adequate removal of the general parameter (suspended solids) in turn provides for adequate removal of the more specific parameters indicated. This does not hold true when certain of the parameters are in the dissolved state; however, in the case of iron oxides generated in the iron and steelmaking processes, they are for themost part insoluble in the relatively neutral effluents in which they are contained. The absence of apparent less important parameters from the guidelines in no way endorses unrestricted discharge of same.

The recommended effluent limitations guidelines resulting from this study for BPCTCA are summarized in Tables 65 to 76. These tables also list the control and treatment technology applicable or normally utilized to reach the constituent levels indicated. These effluent limitations proposed herein are by no means the absolute lowest values attainable (except where no discharge of process waste water pollutants is recommended) by the indicated technology, but moreover they represent values which can be readily <u>controlled</u> <u>around</u> on a day by day basis.

It should be noted that these effluent limitations represent values not to be exceeded by any 30 continous day average. The maximum daily effluent loads per unit of production should not exceed these values by a factor of more than 2. In the absence of sufficient performance data from the industry to establish these factors on a statistical basis, the factor of 2 was chosen in consideration of the operating variations allowed for in selecting the 30 continous day average limitations.

Discussion By Subcategories:

At least one plant in the beehive, coke, sintering, blast furnace (iron), BOF (semi-wet), BOF (wet) electric furnace (semi-wet), vacuum degassing and continuous casting subcategories, are presently achieving the effluent loads that are specified herein and are doing so by achieving the flows on which these limitations are based. No plants in the other subcategories are presently achieving the total effluent quality proposed. However, each of the control techniques is presently employed at individual plants to achieve BPCTCA effluent limitations for specific contaminants listed. In each case where inadequate control was found, corrective measurers could be applied to attain recommended sources.

The rationale used for developing the BPCTCA effluent limitations guidelines is summarized below for each of the subcategories. All effluent limitations guidelines are presented on a "gross" basis since for the most part, removals are relatively independent of initial concentrations of contaminants. The ELG's are in kilograms of pollutant per metric ton of product or in pounds of pollutant per 1,000 pounds of product and in these terms only. The ELG's are not a limitation on flow, type of technology to be utilzed, or concentrations to be achieved. These items are listed only to show the basis for the ELG's and may be varied as the discharger desires so long as the ELG loads per unit of production are met.

Coke Making By-Product Operation

Following is a summary of the factors used to establish the effluent limitation guidelines applying to coke making by-product. As far as possible, the stated limits are based upon performance levels attained by the selected coke plants surveyed during this study. Where treatment levels can be improved by application of additional currently available control and treatment technology, the anticipated reduction of waste loads was included in the estimates. Three of the four plants surveyed were producing less than 733 l of effluent/kkg (175 gal/ton) of coke produced. The fourth plant was diluting their effluent with contaminated final cooler water. Two of the four plants were disposing of a portion of their wastes in coke quenching. Even if this practice is discontinued, it can still be shown that the effluent can be reduced to 733 l/kkg (175 gal/ton) by employing internal recycle followed by minimal blowdown on the final cooler waters. This is summarized as follows:

Waste ammonia liquor	104 l/kkg	25 gal/ton
Steam condensate	75 l/kkg	18 gal/ton
Benzol plant wastes	125 l/kkg	30 gal/ton
Final cooler blowdown	84 l/kkg	20 gal/ton
Barometric condenser effluent	342 l/kkg	82 gal/ton
TOTAL	730 l/kkg	175 gal/ton

TABLE 65

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

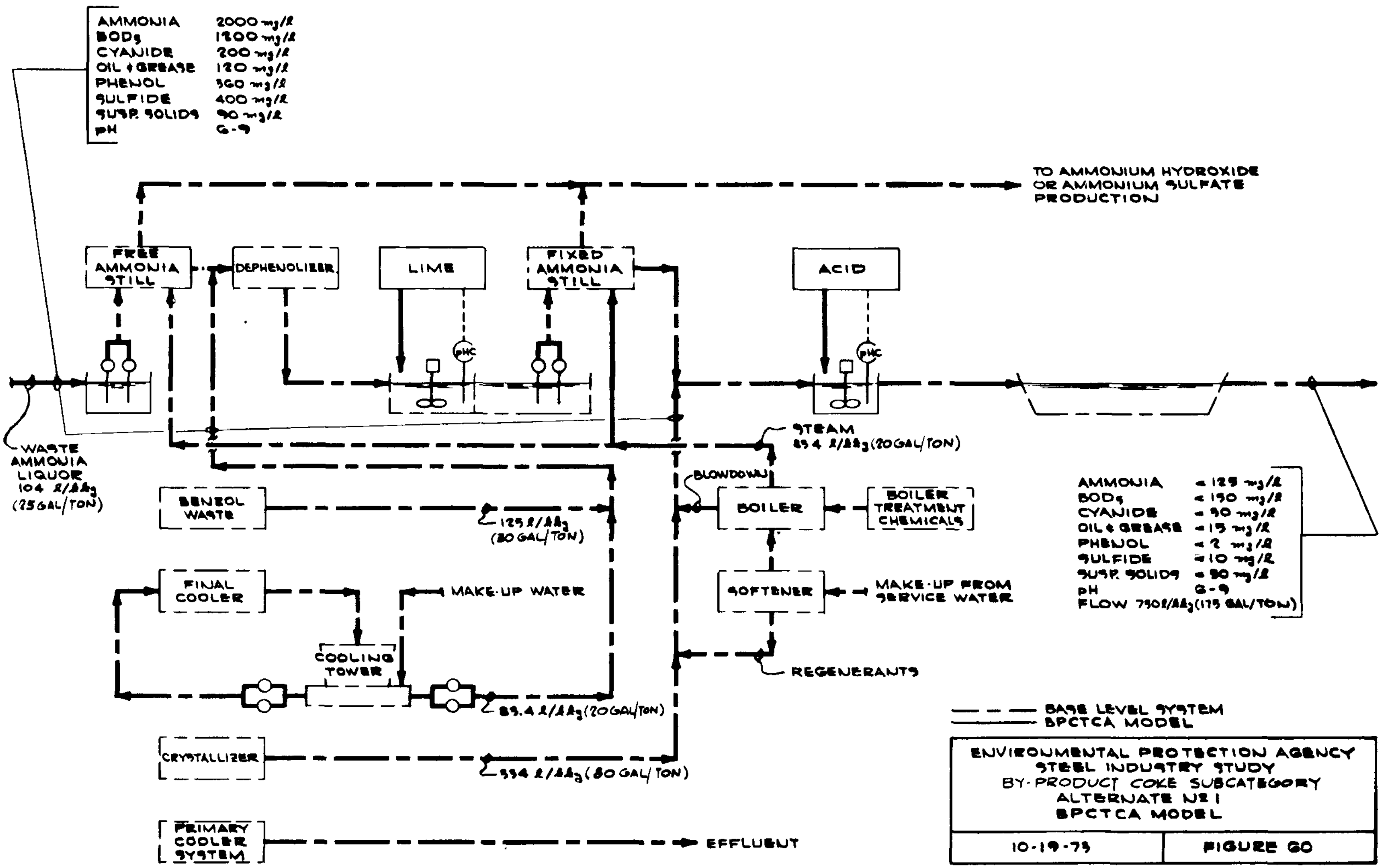
SUBCATEGORY By-Product Coke

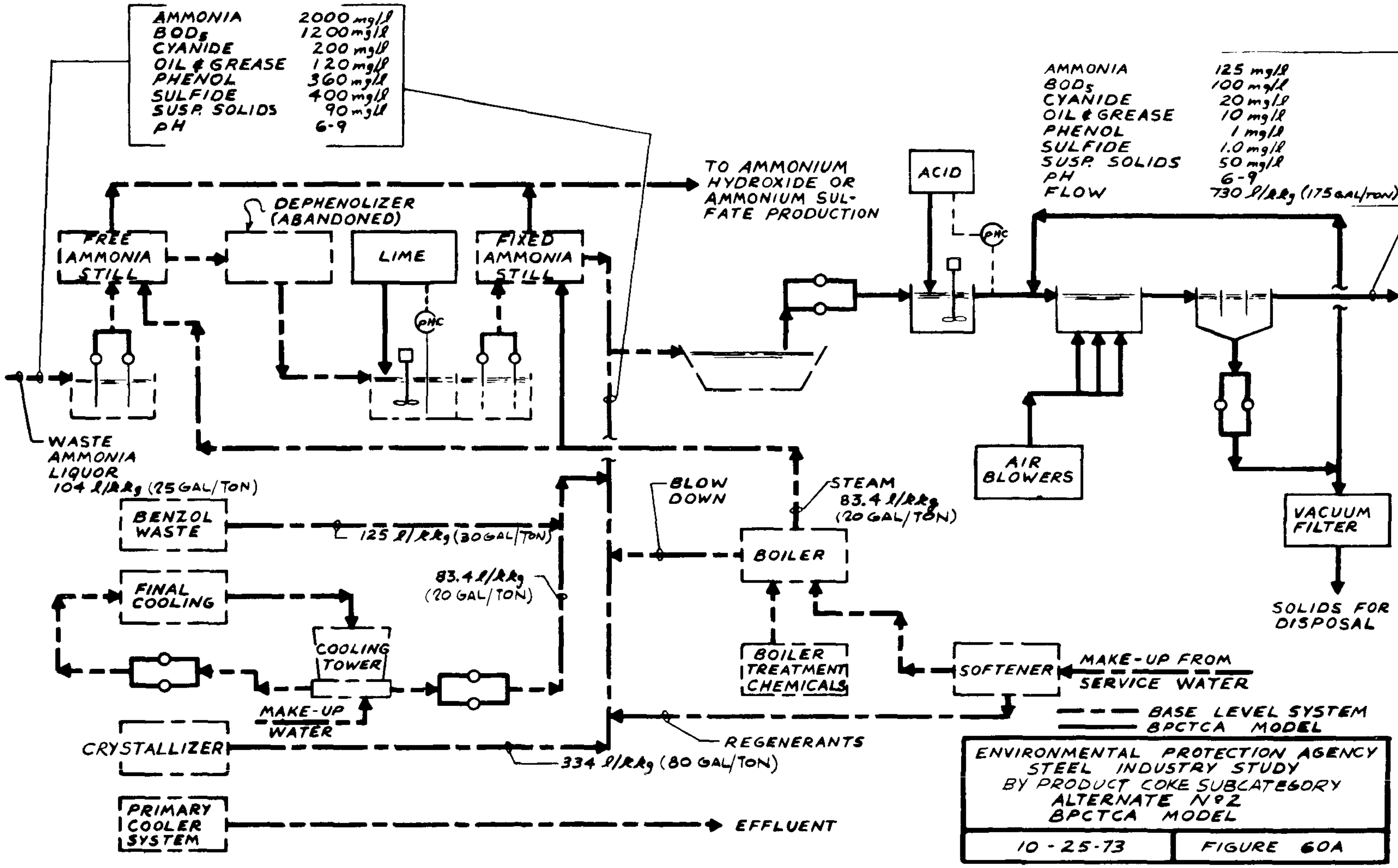
CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BPCTCA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
*$Cyanide_T$	0.0219	30	Weak ammonia liquor equalization and storage		
Phenol	0.0015	2	Free and fixed leg ammonia still operation with lime addition		
Ammonia (as NH_3)	0.0912	125	Dephenolization		
BOD_5	0.1095	150	Sedimentation	0.173	0.157
Oil and Grease	0.0109	15	Final cooler blowdown to dephenolizer		
Suspended Soilds	0.0365	50	Benzol wastes blowdown to dephenolizer		
pH	6.0-9.0		Once through crystallizer effluent to sedimentation		
			pH neutralization		

Flow: Most probably value for tight system is 730 liters effluent per kkg of coke produced (175 gal/ton) (excluding all non contact cooling water.

(1) Kilograms per metric ton of coke produced or pounds per 1,000 pounds of coke produced.
(2) Milligrams per liter based on 730 liters effluent per kkg of coke produced (175 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

* Total cyanide


AMMONIA 2000 mg/l
BOD5 1200 mg/l
CYANIDE 200 mg/l
OIL & GREASE 120 mg/l
PHENOL 360 mg/l
SULFIDE 400 mg/l
SUSP. SOLIDS 90 mg/l
pH 6-9
TO AMMONIUM HYDROXIDE OR AMMONIUM SULFATE PRODUCTION
FREE AMMONIA STILL
DEPHENOLIZER
LIME
FIXED AMMONIA STILL
ACID
pHC
WASTE AMMONIA LIQUOR 104 l/kkg (25 GAL/TON)
STEAM 83.4 l/kkg (20 GAL/TON)
BLOWDOWN
BENZOL WASTE
125 l/kkg (30 GAL/TON)
BOILER
BOILER TREATMENT CHEMICALS
FINAL COOLER
MAKE-UP WATER
SOFTENER
MAKE-UP FROM SERVICE WATER
COOLING TOWER
REGENERANTS
83.4 l/kkg (20 GAL/TON)
CRYSTALLIZER
334 l/kkg (80 GAL/TON)
PRIMARY COOLER SYSTEM
EFFLUENT
AMMONIA ≤ 125 mg/l
BOD5 ≤ 150 mg/l
CYANIDE ≤ 50 mg/l
OIL & GREASE ≤ 15 mg/l
PHENOL ≤ 2 mg/l
SULFIDE ≤ 10 mg/l
SUSP. SOLIDS ≤ 50 mg/l
pH 6-9
FLOW 730 l/kkg (175 GAL/TON)
BASE LEVEL SYSTEM
BPCTCA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE No 1
BPCTCA MODEL
10-19-73
FIGURE 60


AMMONIA 2000 mg/l
BOD5 1200 mg/l
CYANIDE 200 mg/l
OIL & GREASE 120 mg/l
PHENOL 360 mg/l
SULFIDE 400 mg/l
SUSP. SOLIDS 90 mg/l
pH 6-9
TO AMMONIUM HYDROXIDE OR AMMONIUM SULFATE PRODUCTION
DEPHENOLIZER (ABANDONED)
FREE AMMONIA STILL
LIME
FIXED AMMONIA STILL
PHC
WASTE AMMONIA LIQUOR 104 l/kkg (25 GAL/TON)
BENZOL WASTE
125 l/kkg (30 GAL/TON)
FINAL COOLING
COOLING TOWER
MAKE-UP WATER
83.4 l/kkg (20 GAL/TON)
CRYSTALLIZER
334 l/kkg (80 GAL/TON)
PRIMARY COOLER SYSTEM
EFFLUENT
BLOW DOWN
STEAM 83.4 l/kkg (20 GAL/TON)
BOILER
BOILER TREATMENT CHEMICALS
SOFTENER
MAKE-UP FROM SERVICE WATER
REGENERANTS
ACID
AIR BLOWERS
AMMONIA 125 mg/l
BOD5 100 mg/l
CYANIDE 20 mg/l
OIL & GREASE 10 mg/l
PHENOL 1 mg/l
SULFIDE 1.0 mg/l
SUSP. SOLIDS 50 mg/l
pH 6-9
FLOW 730 l/kkg (175 GAL/TON)
VACUUM FILTER
SOLIDS FOR DISPOSAL
BASE LEVEL SYSTEM
BPCTCA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY PRODUCT COKE SUBCATEGORY
ALTERNATE No 2
BPCTCA MODEL
10-25-73
FIGURE 60A

The ELG's were therefore established on an effluent flow basis of 730 l/kkg (175 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies.

Some by-products coke plants are required to install and operate desulfurization units for separate removal of hydrogen sulfide from coke oven gas. The most common H_2S recovery process consists of a chamber where potash or soda ash slurry is used as a scrubbing medium for absorbing hydrogen sulfide, which is in turn liberated by distillation under vacuum. Up to 83 additional liters/kkg (20 gal/ton) of contaminated condensate is produced per ton of coke. This waste is returned to the ammonia still for treatment, where its volume is increased to 104 l/kkg (25 gal/ton) of coke by the addition of lime slurry and further condensation of steam. Plants operating this type of desulfurization equipment will generate up to 834 l/kkg (200 gal/ton) of waste water, instead of the 730 l/kkg (175 gal/ton) shown above.

Phenol

All of the plants surveyed were treating for phenol reduction by either solvent extraction or biological oxidation. One of the four plants was using biological treatment and was obtaining less than 0.1 mg/l phenol in the final effluent. Another plant, using solvent extraction techniques, was producing a dephenolizer effluent containing less than 0.5 mg/l of phenol. However, this effluent was mixed with untreated barometric condenser effluent to produce a final effluent containing 1.37 mg/l of phenol. It became evident from review of the respective plant flow sheets that the remainder of the plants surveyed could accomplish similar reductions by treating their barometric condenser effluent and by tightening up on the final cooling water discharge so as to be able to route the blowdown through the treatment system thereby avoiding unnecessary dilution or contamination of the final treated effluent. The ELG for phenol was therefore based on 2 mg/l at 730 l/kkg (175 gal/ton) and the recommended control and treatment technologies for accomplishing this are as shown in Table 65. This guideline should apply to the BPCTCA standard since it should be readily attainable under the constraints and definitions of the BPCTCA guidelines.

Cyanide

None of the plants surveyed were intentionally practicing cyanide removal, except for the reduction coincidental to ammonia stripping, phenol extraction or biological processes employed for ammonia and phenol removals. Two of the plants were discharging relatively high loads of cyanides, either as untreated crystallizer effluent or through contamination of final cooling water discharges. The remaining two plants were recycling such waste streams through treatment, and yielded cyanide concentrations of 38 and 68 mg/l in effluent flows of 450 and 170 l/kkg (108 and 41 gal/ton) respectively. These loads would be equivalent to 23 and 16 mg/l based on a 730 l/kkg (175 gal/ton) total effluent flow. The smaller of these two concentrations reflects the load from a plant which currently disposes of a portion of the raw waste load as quench water. This practice is not appicable to many areas where air pollution problems must be considered, and this waste should be routed to treatment instead. For this reason, a somewhat higher cyanide load would be expected in this waste water discharge.

The technologies for accomplishing this level of treatment are shown in Table 65.

Ammonia

Of the four by-product coke plants surveyed, only two were operating both legs of their ammonia stills to achieve significant stripping of the fixed ammonia waste loads. These plants discharged 471 and 138 mg/l at flow rates of 171 l/kkg (41 gal/ton) and 217 l/kkg (52 gal/ton) respectively. Equivalent to concentrations of 110 and 41 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. Since more operating data on performance of free and fixed stills was not available, the ELG for ammonia has been conservatively set at 125 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. By-product coke plants efficiently operating free and fixed leg ammonia stills currenlty achieve this limit.

BOD5

The four plants surveyed were discharging effluents containing 64, 23, 537 and 5 mg/l BOD5 at discharge flow rates of 650, 450, 171 and 19,182 l/kkg (156, 108, 41 and 4,600 gal/ton) respectively. Basing these waste loads on a uniform 730 l/kkg (175 gal/ton) discharge flow rate results in concentrations of 57, 14, 126 and 131 mg/l respectively. The lowest concentration results from a biological oxidation treatment system. The other three values are achieved by conventional physical/chemical treatment systems. The ELG for BOD5 has been conservatively set at 150 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. All four plants surveyed are achieving this limit.

Oil and Grease

Oil and grease concentration data were collected at 3 of the 4 plants surveyed. Despite relatively high raw waste loads (50 - 280 mg/l), final effluent concentrations were reduced during treatment to 2.5, 18.7 and 0.02 mg/l in discharge flow rates of 450, 171 and 19,182 l/kkg (108, 41 and 4,600 gal/ton) respectively. Basing these loads on a uniform 730 l/kkg (175 gal/ton) discharge flow rates results in concentrations too low to accurately measure by the most readily available analytical techniques. The ELG for for oil and grease has been conservatively set at 15 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. All three plants for which oil and grease data are available are achieving this limit.

Suspended Solids

Data on suspended solids were collected at 3 of the 4 plants surveyed. Discharges contined 163, 103 and 7 mg/l suspended solids at flow rates of 450,171 and 19,182 l/kkg (108, 41 and 4,600 gal/ton) respectively. A review of the data from the first plant listed above (the Bio-oxidation Treatment System) revealed an abnormal discharge of suspended solids during one of the four visits to the plant. Portions of the activated sludge biomass were floating to the surface of the aeration loagoon and were being carried out in the effluent. Under more normal operating conditions during three other visits to the same plant, the average concentration of suspended solids in the effluent was 80 mg/l. Using this value, plus the other two plant's values above, and basing three loads on a 730 l/kkg (175 gal/ton) discharges flow rate results in equivalent concentrations of 49, 24 and 184 mg/l respectively. The plant discharging the 19,182 l/kkg (4600 gal/ton) total effluent at a final concentration of only 7 mg/l produced the highest solids load, due to the discharge of most of that flow without treatment. The other two plants were practicing sedimentation, so their effluents provide the basis for establishing an ELG for suspended solids of 50 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. Two of the three plants for which suspended solids data are available normally achieve this limit.

pH

Three of the four plants surveyed fell within the pH constraint range of 6.0 to 9.0 thus providing a basis for establishing this range as the BPCTCA ELG. Any plant falling outside this range can readily remedy the situation by applying appropriate neutralization procedures to the final effluent.

Coke Making Beehive Operation

Currently, two of the three exemplary beehive operations surveyed practice zero (0) aqueous discharge. The recommended BPCTCA limitation is therefore "no discharge of process waste water pollutants." The control and treatment technology required would include provision for an adequate settling basin, and a complete recycle of all water collected from the process back to the process, with fresh water make-up as required. The system reaches equilibrium with respect to critical parameters, but provision must be made for periodic removal of settled solids from the basin. Actual operating costs are modest.

Sintering Operation

The only direct contact process water used in the sintering plant is water used for cooling and scrubbing off gases from the sintering strand. As with steelmaking, there are wet and dry types of systems. The sintering strand generally has two (2) independent exhaust systems,

TABLE 66

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Beehive Coke

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB)	BPCTCA LIMITATIONS mg/l[2]	CONTROL & TREATMENT TECHNOLOGY[3]	ESTIMATED[4] TOTAL COST $/KKg	ESTIMATED[4] TOTAL COST $/TON
*Cyanide$_T$	No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water)		Settling basin; complete recycle with no aqueous blowdown - make-up water as required. System reaches equilibrium with respect to critical parameters.	0.0527	0.0478
Phenol					
Ammonia (as NH_3)					
BOD_5					
Oil and grease					
Suspended Solids					
pH					
Flow					

(1) Kilograms per metric ton of coke produced or pounds per 1,000 pounds of coke produced.
(2) Milligrams per liter based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

* Total cyanide

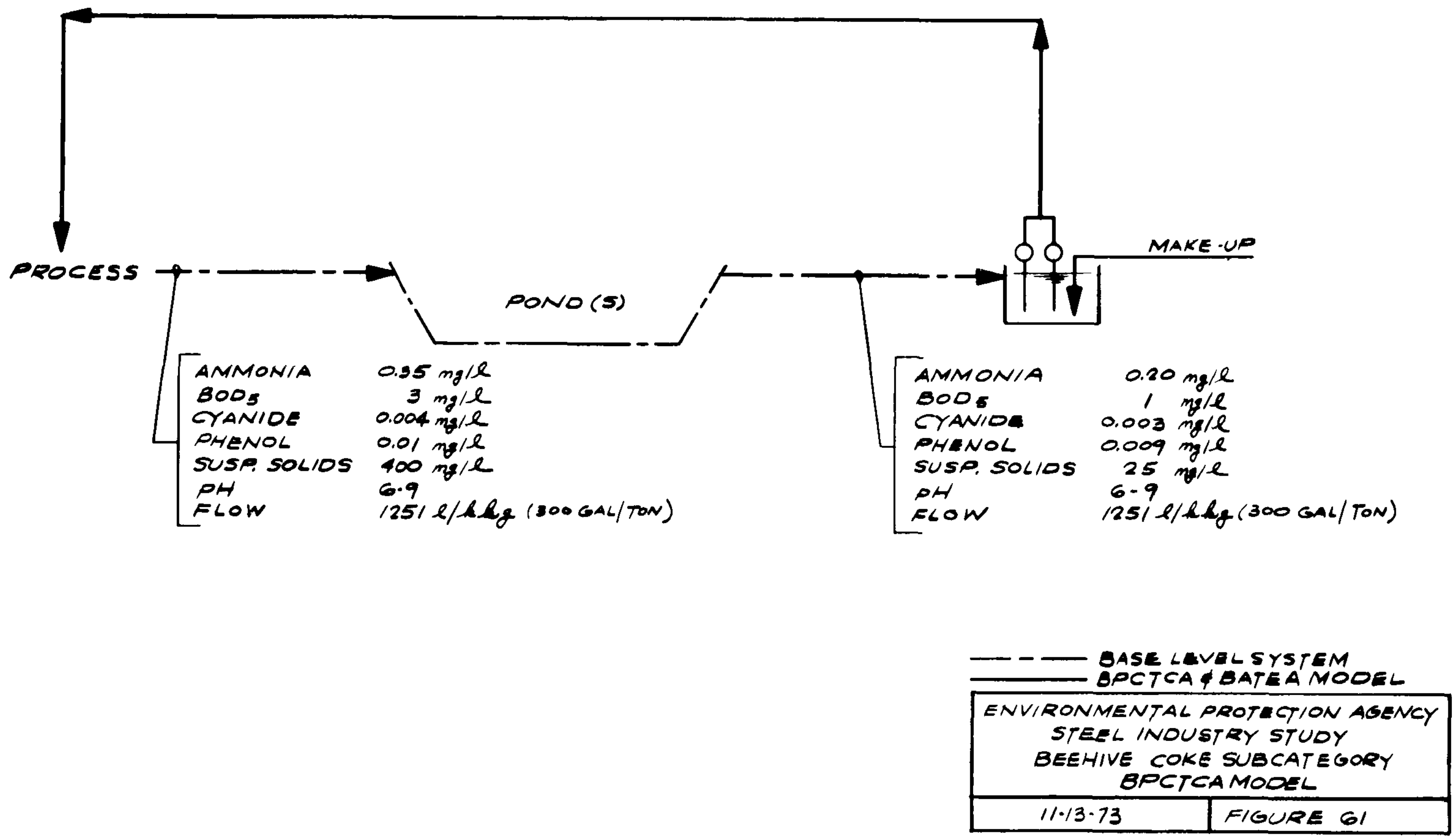

PROCESS
POND (5)
MAKE-UP
AMMONIA 0.35 mg/l
BOD5 3 mg/l
CYANIDE 0.004 mg/l
PHENOL 0.01 mg/l
SUSP. SOLIDS 400 mg/l
pH 6-9
FLOW 1251 l/kkg (300 GAL/TON)
AMMONIA 0.20 mg/l
BOD5 1 mg/l
CYANIDE 0.003 mg/l
PHENOL 0.009 mg/l
SUSP. SOLIDS 25 mg/l
pH 6-9
FLOW 1251 l/kkg (300 GAL/TON)
BASE LEVEL SYSTEM
BPCTCA & BATEA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE SUBCATEGORY
BPCTCA MODEL
11-13-73
FIGURE G1

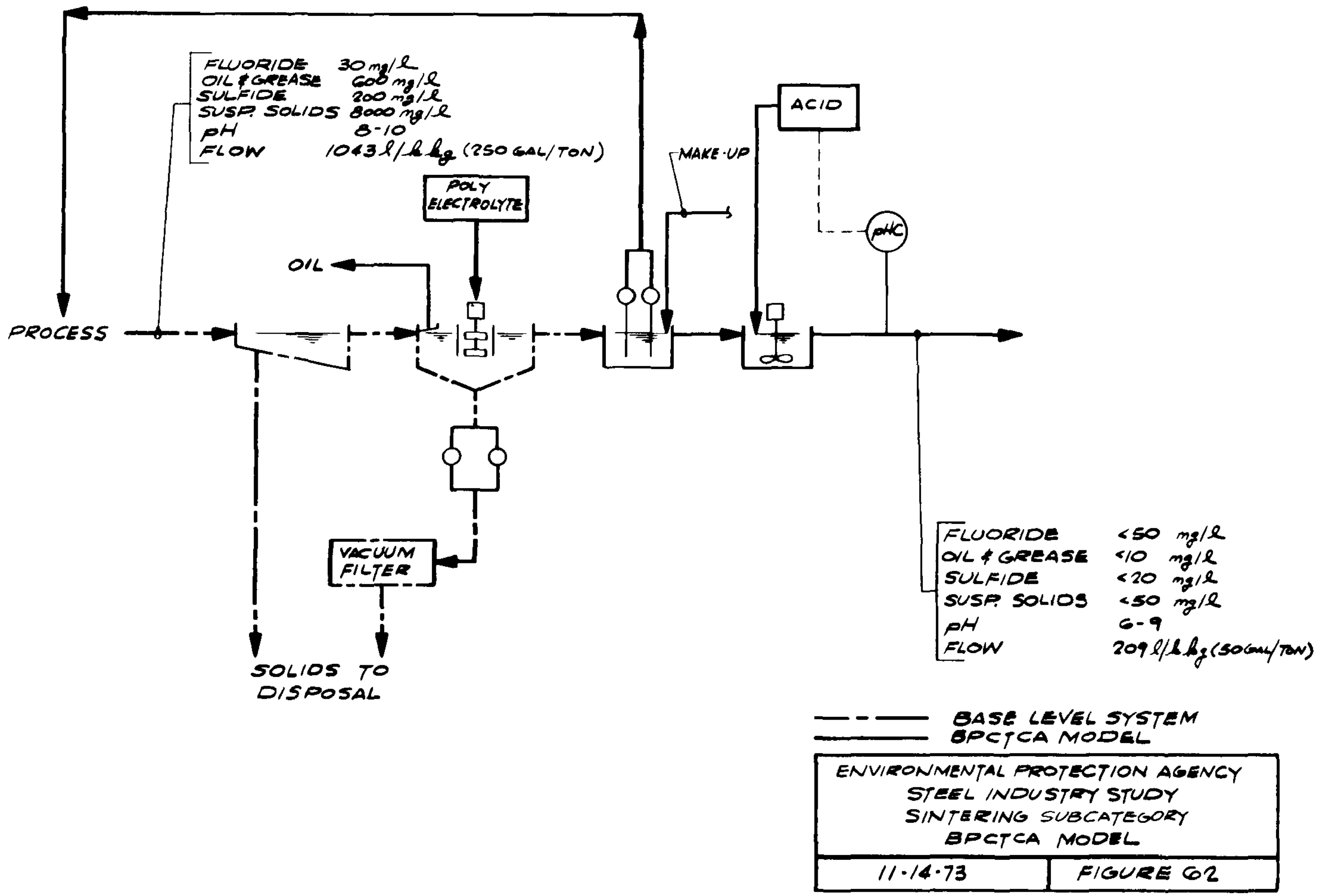
TABLE 67

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Sintering

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BPCTCA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
Suspended Solids	0.0104	50	Thickener with chemical flocculation; tight recycle with minimal blowdown to control cycles of concentration		
Oil and Grease	0.0021	10	Natural adsorption to settling solids in thickener; provision required for surface skimming	0.0565	0.0513
pH	6.0-9.0		Neutralization		
Flow:	Most probable value for tight system is 209 liters effluent per kkg of sinter produced (50 gal/ton)(excluding all non contact cooling water).				

(1) Kilograms per metric ton of sinter produced or pounds per 1000 pounds of sinter produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of sinter produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only <u>incremental</u> costs required above those facilities which are normally existing within a plant.


FLUORIDE 30 mg/l
OIL & GREASE 600 mg/l
SULFIDE 200 mg/l
SUSP. SOLIDS 8000 mg/l
pH 8-10
FLOW 1043 l/kkg (250 GAL/TON)
POLY ELECTROLYTE
OIL
PROCESS
MAKE-UP
ACID
pHC
VACUUM FILTER
SOLIDS TO DISPOSAL
FLUORIDE <50 mg/l
OIL & GREASE <10 mg/l
SULFIDE <20 mg/l
SUSP. SOLIDS <50 mg/l
pH 6-9
FLOW 209 l/kkg (50 GAL/TON)
BASE LEVEL SYSTEM
BPCTCA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING SUBCATEGORY
BPCTCA MODEL
11-14-73
FIGURE 62

the dedusting at discharge end of machine and combustion and exhaust system for the sinter bed. Each one of these systems can either be wet or dry as defined in the process flow diagrams types I, II, III, shown as Fiquires 6, 7, and 8, respectively.

Generally the sinter bed exhaust systems are dry precipitation systems with the dedusting exhaust systems split between wet and dry.

Three sintering plants were visited, but two of the three systems were deleted from the comparison. These two systems were deleted due to the intricate wastewater treatment system which was utilized which made separate identification of unit raw waste and unit effluent loads from the sintering operation obscure.

The third sintering plant had wet scrubber systems for both the dedusting and sinter bed exhaust systems. The wastewater treatment system was comprised of classifier and thickener with recirculation of a portion of the thickener overflow with the difference going to blowdown. The underflow was filtered through vacuum filters.

For the one plant considered under this study, the effluent flow was 475 l/kkg (114 gal/ton) of sinter produced. This value, however, represents a blowdown equivalent to approximately 30% of the process recycle flow of 1422 l/kkg (341 gal/ton). The 114 gal/ton effluent flow also represents the total blowdown from this combined sinter plant - blast furnace waste treatment and recycle facility. Therefore, the magnitude of the effluent flow was considered inadequate, i.e. excessive, since simply tightening up the recycle loop can reduce the effluent discharge by more than 50 percent. In doing this, more attention may have to be paid to control of heat buildup and scaling and/or corrosive conditions in the recycle system. The ELG's were therefore established on the basis of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. This proposed 209 l/kkg (50 gal/ton) is identical to the effluent flow limitations actually found (under this study) for the Open Hearth and BOF gas scrubber recycle systems, thus the technology should be readily transferable to a sinter plant since the type of recycle system and many of the aqueous contaminants are identical. This guideline should apply to the BPCTCA limitations since this value is readily attainable under the constraints and definitions of the BPCTCA guidelines.

After reviewing the laboratory analyses, the critical parameters were established as suspended solids, oils and grease, sulfides, fluoride, and pH. However, cost considerations dictated that treatment systems for sulfide and fluoride reduction could only be included in the BATEA treatment models. The ELG's for BPCTCA were, therefore, established on the basis of 209 l/kkg (50 gal/ton) of sinter produced and the concentrations achievable by the applicable treatment technologies indicated below.

Suspended Solids

The one plant studied showed less than 10 mg/l total suspended solids in the final effluent. This excellent reduction can be credited to the presence of substantial oil in the raw waste which tends to act as a mucilage on the suspended solids. This like phenomena has long been known to be responsible for enhancing removal of fine suspended solids in deep bed sand filters. The ELG for total suspended solids was, however, based on 50 mg/l at 209 l/kkg (50 gal/ton) to be consistent with the ELG set for BPCTCA for this parameter for all other subcategories, except one which could not achieve this concentration. The technologies for achieving this are as shown in Table 67.

Oil and Grease

Oil was found to be 1 mg/l in the final effluent of the one plant studied. It is felt a less restrictive ELG based on 10 mg/l at 209 l/kkg (50 gal/ton) should be adopted since only one plant was used in the survey and for the reasons stated in the discussion under Coke Making By Product Operations. The technologies for achieving this ELG are presented in Table 67 and for the most part center around the natural adsorption to the suspended solids as previously discussed.

pH

For the one plant studied, the pH was found to be 12.7 in the final effluent, apparently due to the use of lime fluxing agents in the sintering process. Although the presence of lime in the process water enhances removal of fluorides, pH levels in this range would definitely have to be classed as harmful and the utilization of cost effective control technology judged to be <u>inadequate</u>. Therefore, the BPCTCA permissible range for pH was set at 6.0-9.0. This range can be attained by use of conventional, well-established neutralization techniques.

Blast Furnace (Iron) Subcategory

Waste treatment practices in blast furnace operations center primarily around removal of suspended solids from the contaminated gas scrubber waters. In past practice, little attention has been paid to treatment for other aqueous pollutants in the discharge. Water conservation is practiced in many plants by employing recycle systems. Three of the four plants surveyed were practicing tight recycle with minimum blowdown. Discharges from these three plants were all under 521 l/kkg (125 gal/ton) of iron produced. The ELG's were therefore established on the basis of an effluent flow of 521 l/kkg (125 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. The fourth plant surveyed was running close to a once-through system and was judged <u>inadequate</u> with respect to water conservation, since blast furnace recycle is a well established art.

TABLE 68

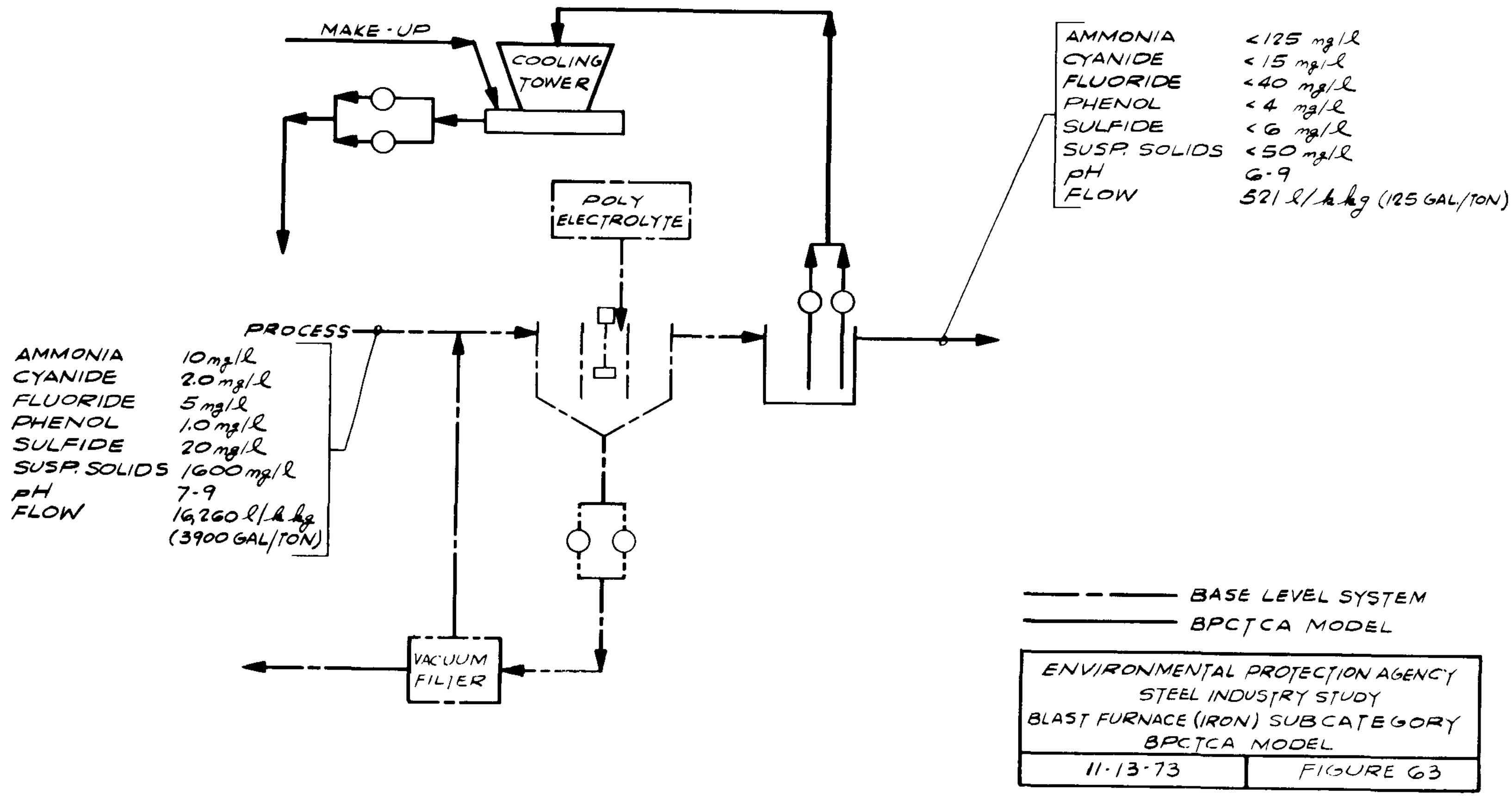
BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Blast Furnace (Iron)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB)	mg/l [2]	CONTROL & TREATMENT TECHNOLOGY [3]	ESTIMATED [4] TOTAL COST $/KKg	$/TON
Suspended Solids	0.0260	50	Thickening with polymer addition		
*Cyanide$_T$	0.0078	15	Vacuum filtration of thickener sludge		
Phenol	0.0021	4	Recycle loop utilizing cooling tower	0.271	0.246
Ammonia (as NH_3)	0.0651	125			
pH	6.0-9.0				
Flow:	Most probable value for tight system is 522 liters effluent per kkg of iron produced (125 gal/ton) (excluding all non contact cooling water)				

(1) Kilograms per metric ton of iron produced or pounds per 1,000 pounds of iron produced.
(2) Milligrams per liter based on 522 liters effluent per kkg of iron produced (125 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

* Total cyanide


MAKE-UP
COOLING TOWER
POLY ELECTROLYTE
PROCESS
AMMONIA 10 mg/l
CYANIDE 2.0 mg/l
FLUORIDE 5 mg/l
PHENOL 1.0 mg/l
SULFIDE 20 mg/l
SUSP. SOLIDS 1600 mg/l
pH 7-9
FLOW 16,260 l/kkg (3900 GAL/TON)
VACUUM FILTER
AMMONIA <125 mg/l
CYANIDE <15 mg/l
FLUORIDE <40 mg/l
PHENOL <4 mg/l
SULFIDE <6 mg/l
SUSP. SOLIDS <50 mg/l
pH 6-9
FLOW 521 l/kkg (125 GAL/TON)
BASE LEVEL SYSTEM
BPCTCA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE (IRON) SUBCATEGORY
BPCTCA MODEL
11-13-73
FIGURE 63

A survey of four iron producing blast furances resulted in the following recommendations for effluent standards:

Suspended Solids

The three plants surveyed and operating on a tight recycle were experiencing suspended solids in their effluents ranging from 39 to 85 mg/l, whereas the plant operating close to once-through was achieving 11 mg/l suspended solids in the final effluent. This could be expected since higher TDS levels in recycle systems have been known to inhibit agglomeration and settling of suspended solids. The technology is well established for reducing iron laden suspended solids to less than 50 mg/l. The majority of plants around the country are operating on a once-through basis. The BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 521 l/kkg (125 gal/ton) based on the proposed use of known technology for reducing blast furnace suspended solids to the indicated level. Three of the surveyed plants were achieving the proposed effluent load directly and the fourth plant, producing the effluent containing 85 mg/l of suspended solids, was also achieving the proposed effluent load by virtue of further treatment of the blowdown in the sinter plant waste treatment facility.

Cyanide

All of the plants surveyed were experiencing cyanides in their blowdown of 19 mg/l or less. No intentional treatment for cyanide removal was being practiced since the blowdowns were being disposed of on site. The one plant operating on a close to once-through basis was achieving 0.005 mg/l cyanide in the final effluent by the use of alkaline chlorination. The proposed BPCTCA limitation on cyanide is based on 15 mg/l at 521 l/kkg (125 gal/ton). Three of the four plants surveyed are achieving this proposed effluent load directly. The fourth plant was exceeding this load by 12% but the effluent was receiving further treatment in the sinter plant waste treatment facility. The technology for accomplishing this level of treatment are shown in Table 68.

Phenol

Of the four plants surveyed, the effluent phenols ranged from 0.01 to 3.6 mg/l. The close to once-through plant was reducing phenols via the alkaline chlorination system. In the recycle systems, many plants were experiencing reduction of phenols in the cooling tower as evidenced by close examination of the analytical data in and out of the towers. Further reduction of phenols was sometimes noted across the thickeners. Much of the loss of phenol is inherent in the operation of a recycle system. Further reductions could be readily accomplished by discontinuing the use of green coke or coke quenched with water which is contaminated with phenol in the blast furnace. Studies have shown that the adsorbed phenols carry directly through to the blast furnace gas scrubber waters. The proposed BPCTCA limitation for phenols is based on

4 mg/l at 521 l/kkg (125 gal/ton). The technology for accomplishing the proposed limitation is shown in Table 68. All four plants surveyed are currently achieving the proposed BPCTCA effluent limitation for phenol.

Ammonia

The three plants surveyed employing tight recycle were experiencing ammonia values in their blowdown ranging from 78 to 265 mg/l.

The one plant operating on a close to once-through basis was achieving 0.8 mg/l ammonia in the final effluent - probably due to dilution effects as well as oxidation of the ammonia by chlorine. The proposed BPCTCA limitation for ammonia is based on 125 mg/l at 521 l/kkg (125 gal/ton). Table 68 is referred to for further identification of the technology. Three of the plants surveyed are currently achieving the proposed BPCTCA effluent limitation for ammonia. The average effluent load of all four plants surveyed is less than the proposed load limitation.

pH

Of the four plants surveyed, the pH of the effluents fell well within the range of 6.0 - 9.0 which should be established at the BPCTCA permissible range.

Blast Furnace Ferromanganese Operation

Only one operating ferro-manganese furnace was found for the survey. The one plant surveyed was operating with a once-through system on the gas cooler and with a totally closed recycle system on the venturi scrubber. The flow through the gas cooler was 5,700 gallons effluent per ton of ferro-manganese produced. This flow would have to be considered inadequate, i.e. excessive, since there is no reason precluding running a recycle system identical to that of the iron producing blast furnaces. Under the iron producing blast furnace recycle plants, the effluent flow was found to be 521 l/kkg (125 gal/ton) which was equivalent to a blowdown rate of 4.25% of the recycle rate. The proposed BPCTCA limitations are based on an effluent volume of 1042 l/kkg (250 gal/ton) which is 4.25% of the total recycle flow rate on the one ferromanganese blast furnace plant surveyed. The ferromanganese furnace operates at a higher temperature than the blast furnace producing iron and thus requires higher recycle and blowdown rates.

Suspended Solids, Cyanide, Phenol, Ammonia

The above indicated critical parameters are the same pollutants found in iron producing blast furnaces. Because of the higher temperature operation, however, the cyanide and ammonia loads produced are greater.

TABLE 69

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

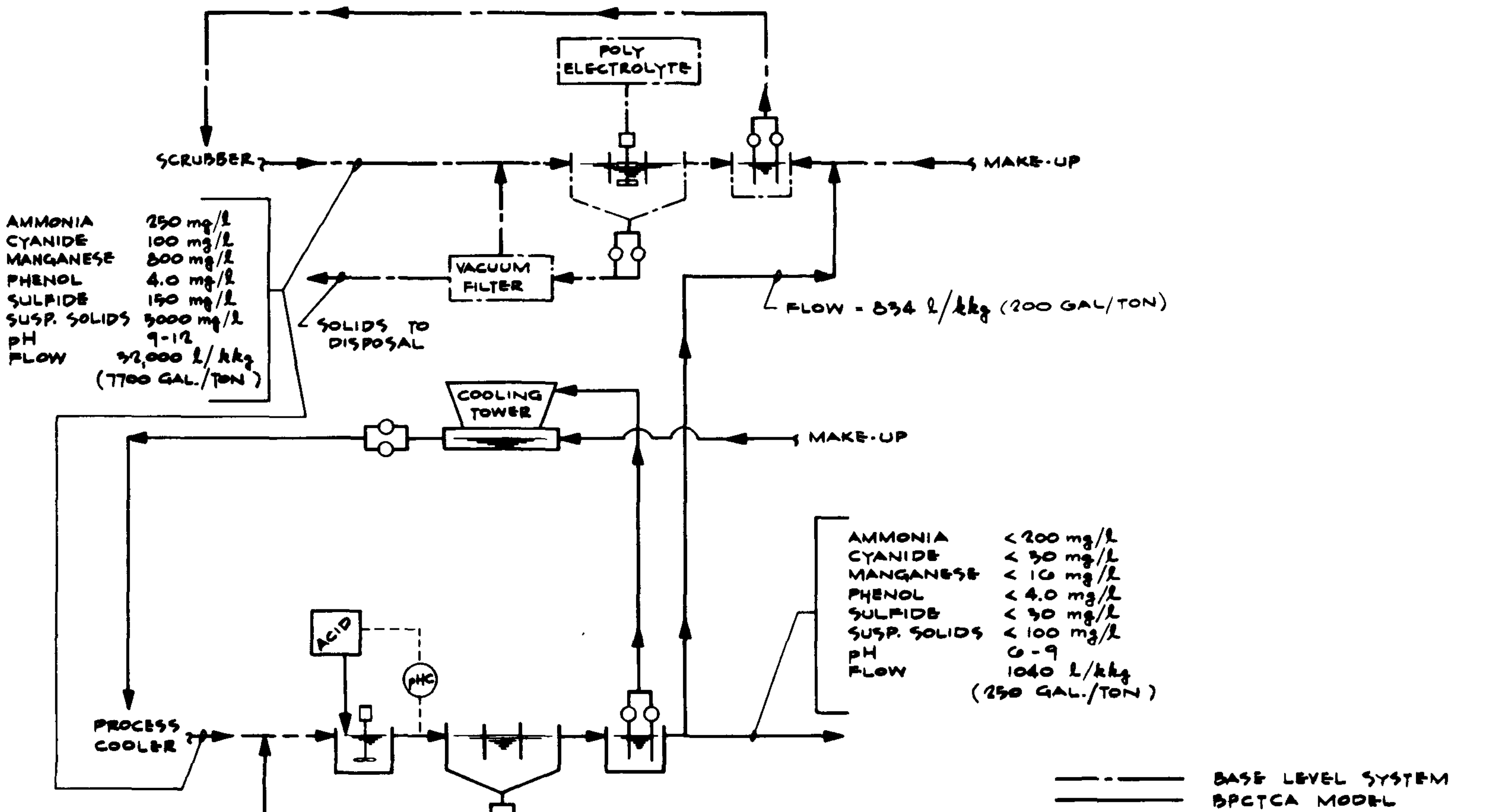
SUBCATEGORY Blast Furnace (Ferromanganese)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB)	BPCTCA LIMITATIONS mg/l[2]	CONTROL & TREATMENT TECHNOLOGY[3]	ESTIMATED[4] TOTAL COST $/KKg	ESTIMATED[4] TOTAL COST $/TON
Suspended solids	0.1043	100	Thickener with polymer additon		
*Cyanide$_T$	0.0312	30	Vacuum filtration of thickener underflow		
Phenol	0.0042	4	Scrubber water recycle with evaporative cooling	1.30	1.18
Ammonia (as NH_3)	0.2086	200	pH adjustment		
pH	6.0-9.0				

Flow: Most probable value for tight system is 1043 liters effluent per kkg of ferromanganese produced (250 gal/ton)(excluding all non contact cooling water)

(1) Kilograms per metric ton of ferromanganese produced, or pounds per 1,000 pounds of ferromanganese produced.
(2) Milligrams per liter based on 1043 liters effluent per kkg of ferromanganese produced (250 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications requried to accept the indicated control and treatment devices. Estimated total costs shown are only incremental required above those facilities which are normally existing within a plant.

*Total cyanide



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE - FERROMANGANESE SUBCATEGORY
BPCTCA MODEL

11-13-73 | FIGURE 64

Since the one plant surveyed was judged to be <u>inadequate</u> with respect to the application of good water conservation practice, the proposed BPCTCA effluent limitations have been based on the loads that can be achieved by a plant equipped with a recycle system producing an effluent of 1042 l/kkg (250 gal/ton) and equipped to neutralize the blowdown. A facility so equipped should achieve the following concentrations:

Suspended Solids	100 mg/l
Cyanide	30 mg/l
Ammonia	200 mg/l
Phenol	4 mg/l

The proposed BPCTCA limitations have been based on these concentrations at a flow of 1042 l/kkg (250 gal/ton). Since the one plant surveyed is not equipped with a recycle system on the gas cooler or for neutralization of the effluent, the surveyed plant does not presently meet the proposed limitations.

<u>pH</u>

The pH of the plant surveyed fell within the range of 6.0 - 9.0 which should be established as the BPCTCA permissible range.

<u>Basic Oxygen Furnace Operation</u>

The only direct contact process water used in the BOF plant is the water used for cooling and scrubbing the off gases from the furnaces. Two methods which are employed and can result in an aqueous discharge are the semi-wet gas cleaning and wet gas cleaning systems as defined in Types II, III, IV and V on Figures 17 to 20, inclusive.

The two semi-wet systems surveyed had different types of waste water treatment systems. The first system was comprised of a drag link conveyor, settling tank, chemical flocculation and complete recycle pump system to return the clarified treated effluent to the gas cleaning system. Make-up water was added to compensate for the evaporative water loss and the system had zero (0) aqueous discharge of blowdown. The second semi-wet system was comprised of a thickener with polyelectrolyte addition followed by direct discharge to the plant sewers on a "once-through" basis.

Because of the nature of these semi-wet systems, direct blowdown is not required when recycle is employed. The systems are kept in equilibrium by water losses to the sludge and to entrainment carry-over into the hot gas stream. Most new wet BOF systems are designed in this manner. The BPCTCA limitations have therefore been established as "no discharge of process waste water pollutants to navigable waters" from BOF shops equipped with semi-wet air pollution control systems.

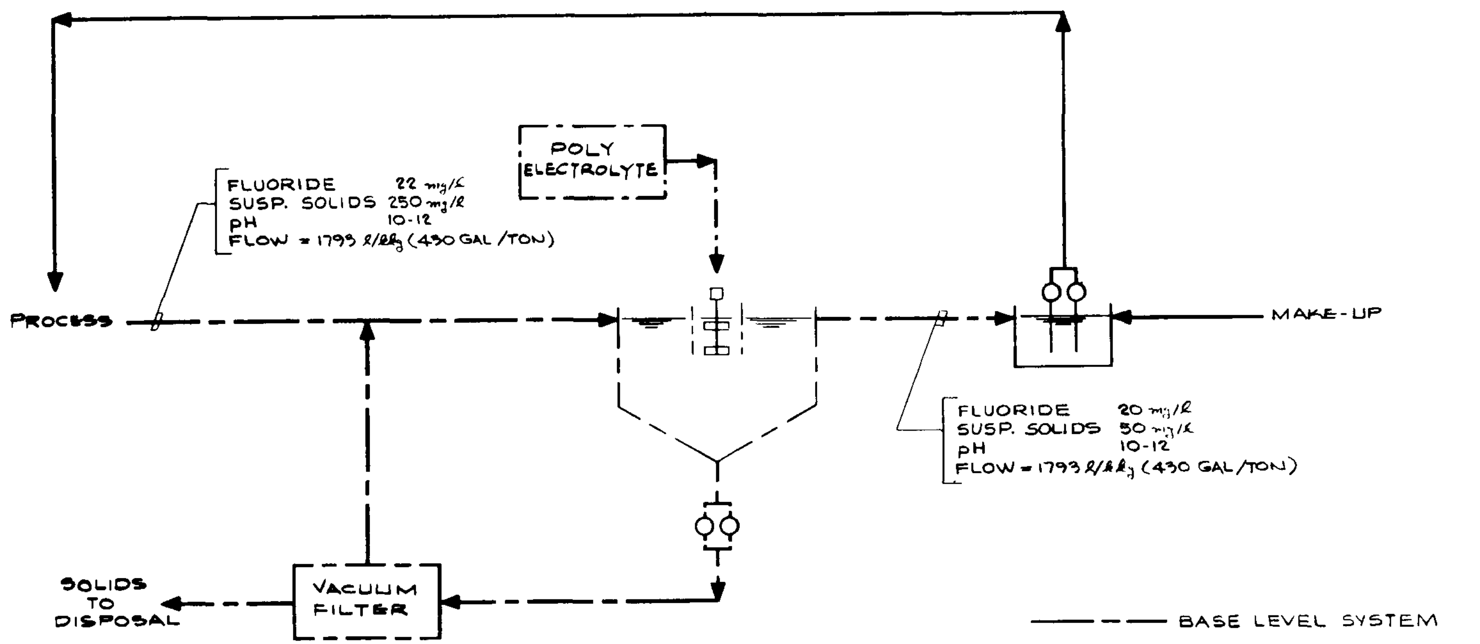
TABLE 70

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Basic Oxygen Furnace (Semi-Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BPCTCA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
Suspended Solids Fluoride pH Flow	No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water)		Settling tank with chemical and/or magnetic flocculation; complete recycle with no aqueous blowdown - makeup water as required; wet sludge to reuse or landfill	0.0241	0.0219

(1) Kilograms per metric ton of steel produced or pounds per 1000 pound of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are nromally existing within a plant.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE (SEMI-WET)
SUBCATEGORY
BPCTCA MODEL

11-15-73 | FIGURE 65

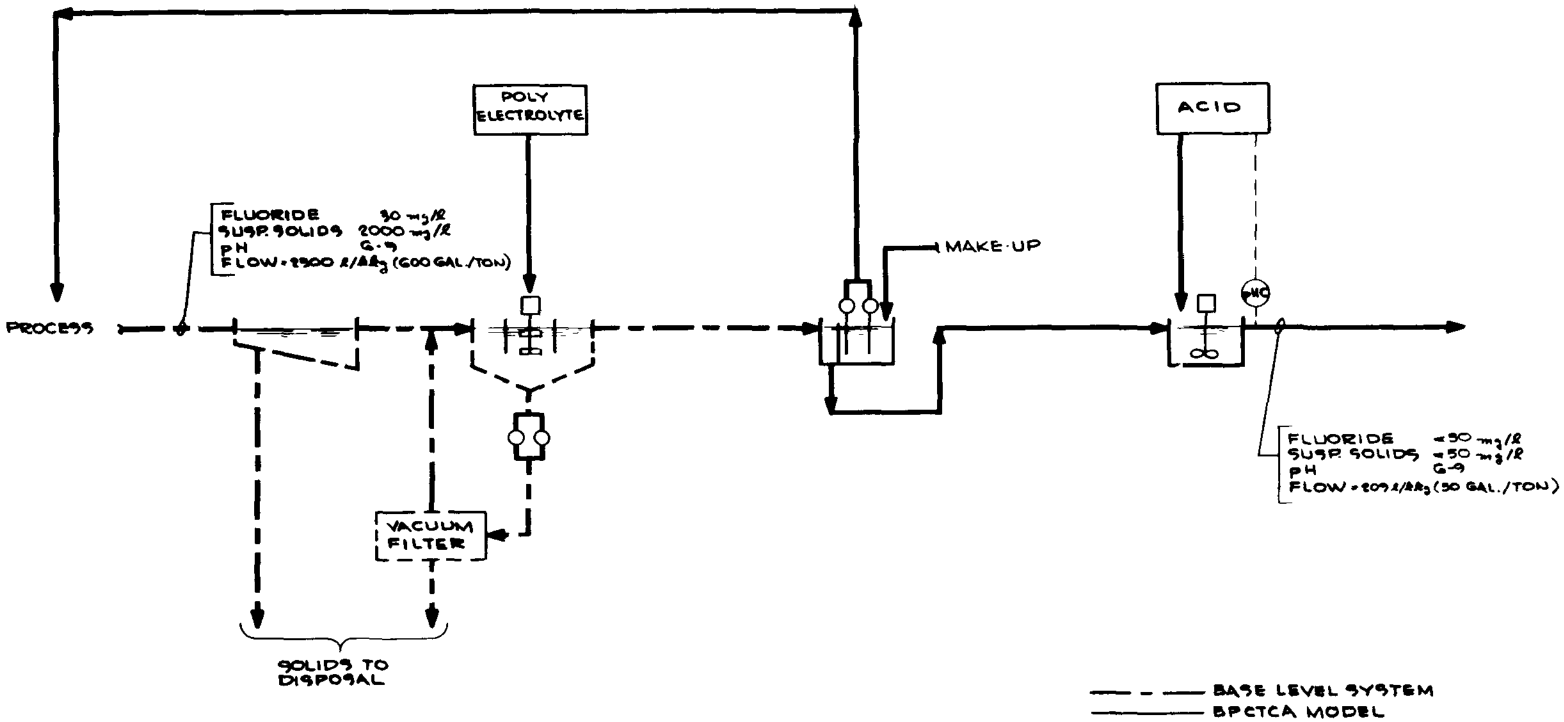
TABLE 71

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Basic Oxygen Furnace (Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0104	50	Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blowdown to control cycles of concentration	0.091	0.082
pH	6.0-9.0		Neutralization		
Flow:	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non contact cooling water)				

(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE (WET)
SUBCATEGORY
BPCTCA MODEL

11-14-73	FIGURE GG

The three BOF wet systems surveyed were generally of the same type and included classifiers and thickeners with recirculation of a portion of the clarified effluent. The blowdown rates were 138, 217, and 905 l/kkg (33, 52, and 217 gal/ton) of steel produced, respectively, with the latter system discharging at a blowdown rate equivalent to 65% of makeup and 25% of the recirculation rate. The first two plants were discharging at a rate equivalent to 5.2 and 11.5% of the recirculation rate. The third plant should be able to reduce the effluent to a rate equivalent to 7.5% of the recirculation rate or 271 l/kkg (65 gal/ton). The average rate of discharge of the three plants would then be 209 l/kkg (50 gal/ton) and this rate and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies has been established as the basis for the BPCTCA limitations proposed. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The effluent suspended solids were 22, 40, and 70 mg/l, respectively, for the three plants surveyed. The clarifier at the latter plant was not equipped with skimming devices and a hose was being used to agitate the surface to break up the foam, thus contributing to a high suspended solids content in the effluent. Even when including this plant the average suspended solids concentration of the three effluents is less than 50 mg/l. As indicated under discussion of blast furnaces, the technology is well established for reducing iron-laden suspended solids to less than 50 mg/l with the use of adequately designed and operated clarifiers and/or chemical and/or magnetic flocculation. Therefore, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 50 gal/ton based on (1) known technology for achieving same in a cost effective manner and (2) the fact that two of the plants surveyed are currently achieving less than this effluent load.

pH

The pH of the three plants surveyed varied from 6.4 to 9.4. As with previous subcategories, the BPCTCA permissible range for pH should be set at 6.0 to 9.0, which can be readily accomplished by using appropriate neutralization techniques.

Open Hearth Furnace Operation

As with the BOF furnaces, only contact process waters were surveyed, sampled and analyzed. Again the only contact process water in the open hearth is the water used for cooling and scrubbing the waste gases from the furnaces. As a general rule, open hearths have dry precipitator systems rather than scrubbers. Therefore, only two open hearth shops were surveyed and each had a wet high energy venturi scrubber system as defined in Types I, II, III shown on Figures 21, 22 and 23, respectively. There are no semi-wet systems for open hearths.

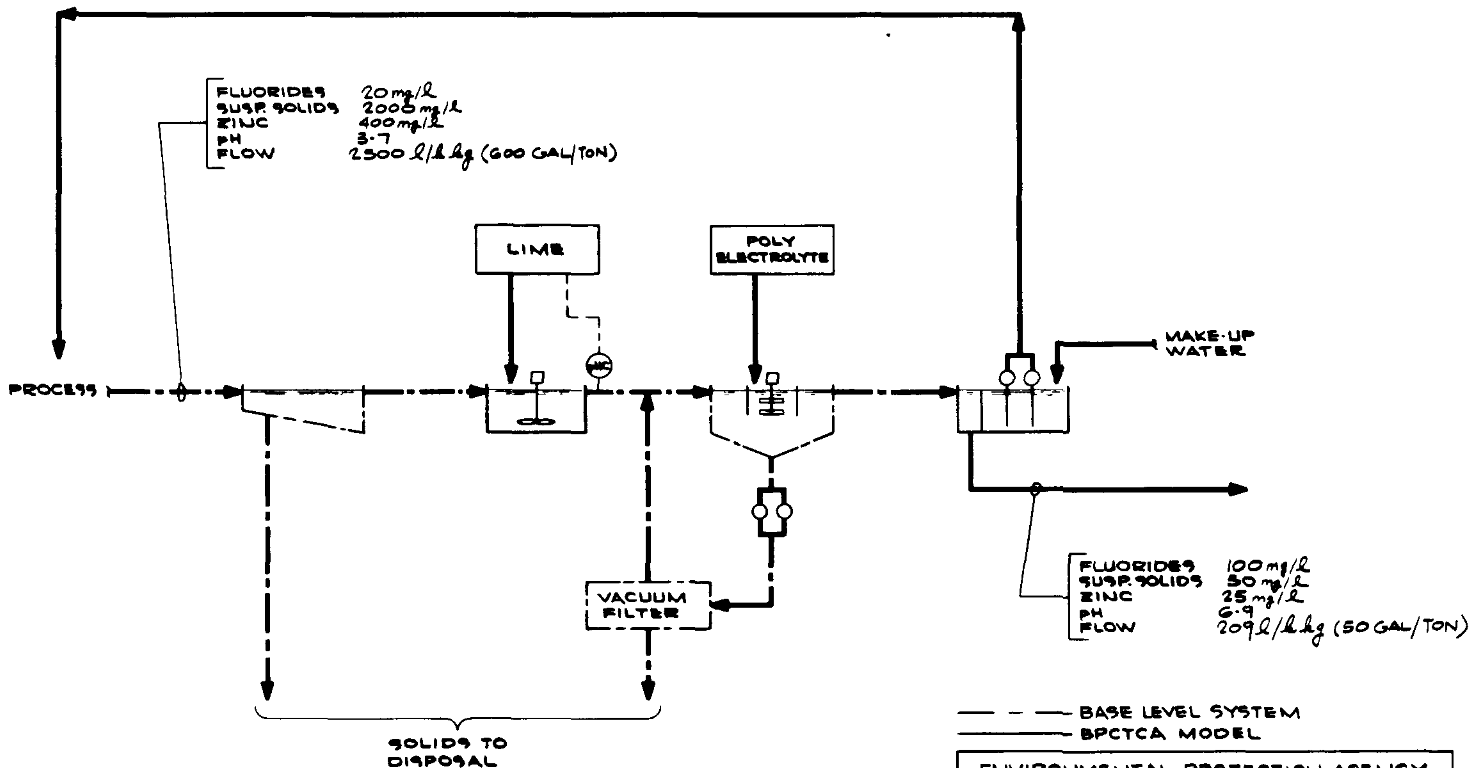
TABLE 72

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Open Hearth Furnace

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BPCTCA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
Suspended Solids	0.0104	50	Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blow-down to control cycles of concentrations	0.0608	0.0552
pH	6.0-9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non contact cooling water)				

(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may very some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE SUBCATEGORY
BPCTCA MODEL

11-14-73	FIGURE G7

Each plant had similar wastewater treatment systems comprised of classifiers, with thickeners with recirculation of a portion of the thickener overflow. One system utilized vacuum filters for thickener underflow while the other system used slurry pumps and pumped the thickener wastes to tank trucks for disposal. The blowdown rates for the two plants were 213 l/kkg (51 gal/ton) and 492 l/kkg (118 gal/ton) which were equivalent to 9.3% and 17.5% of the recycle rates, respectively. These systems can be tightened as was indicated for the BOF and therefore the BPCTCA limitations were established on the basis of effluent volumes of 209 l/kkg (50 gal/ton) of product and the concentrations of the process pollutant parameters achievable by the indicated treatment technologies. This effluent volume is equivalent to the average of the values that would be achieved by reducing blowdowns to 7.5% of the recycle rates.

A review of the data collected resulted in the following effluent guidelines:

Suspended solids

For the two plants surveyed, the effluent suspended solids were 80 and 52 mg/l. As with one of the BOF wet recycle systems surveyed, the clarifier at the former plant was not equipped with skimming devices and a hose was being used to agitate the surface to break up the form, thus contributing to a high solids content in the effluent. Since suspended solids concentrations of 50 mg/l or less can readily be achieved by the use of adequately designed and operated clarifiers, and/or chemical and/or magnetic flocculation, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 209 l/kkg (50 gal/ton), The technologies for achieving this effluent load are shown in Table 72.

pH

The pH was found to be 6.1 and 1.8-3.4, respectively, for the two plants surveyed, with the latter plant being judged inadequate with respect to proper control of pH. The pH range for BPCTCA limitations has been set at 6.0 to 9.0. This range is readily attainable through the use of neturalization techniques as previously discussed.

Electric Arc Furnace Operation

The electric arc furnace waste gas cleaning systems are similar in nature to the BOF, i.e. they may be dry, semi-wet or wet systems as defined in Types I, II, III, and IV shown on Figures 24 through 27, respectively. Four plants were surveyed, two semi-wet and two wet systems.

The two semi-wet systems had similar wastewater treatment systems comparised of a settling tank with drag link conveyor; one system was recycled with no aqueous blowdown while the other system had closely

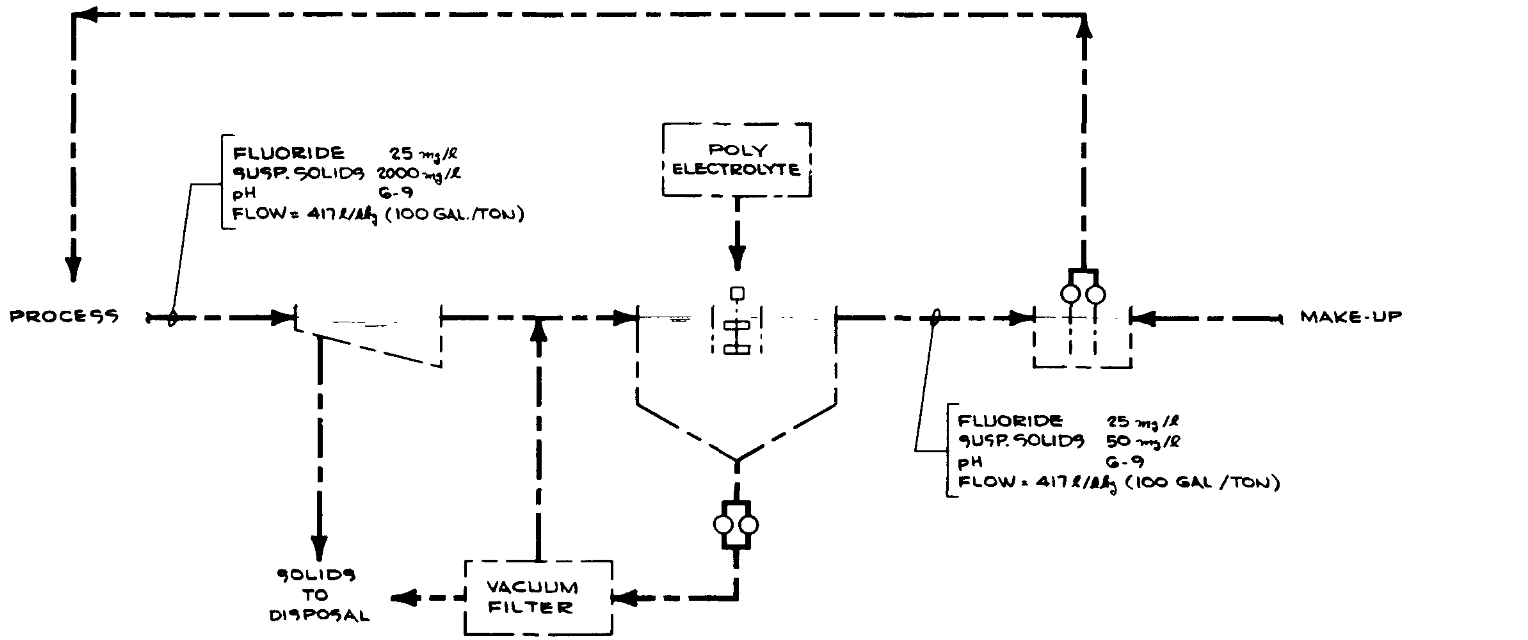
TABLE 73

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Semi-Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg(1) (LB/1000 LB)	mg/l(2)	CONTROL & TREATMENT TECHNOLOGY(3)	ESTIMATED(4) TOTAL COST $/KKg	$/TON
Suspended Solids Fluoride Zinc pH Flow	No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water)		Settling tank with chemical and/or magnetic flocculation; complete recycle with no aqueous blowdown - makeup water as required; or controlled wetting of gases to form sludge only - no recycle or blowdown; wet sludge to reuse or landfill	Zero (0)	

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



— — — BASE LEVEL & BPCTCA MODEL

ENVIRONMENTAL PROTECTION AGENCY STEEL INDUSTRY STUDY ELECTRIC ARC FURNACE (SEMI-WET) SUBCATEGORY BPCTCA MODEL	
11-15-73	FIGURE 68

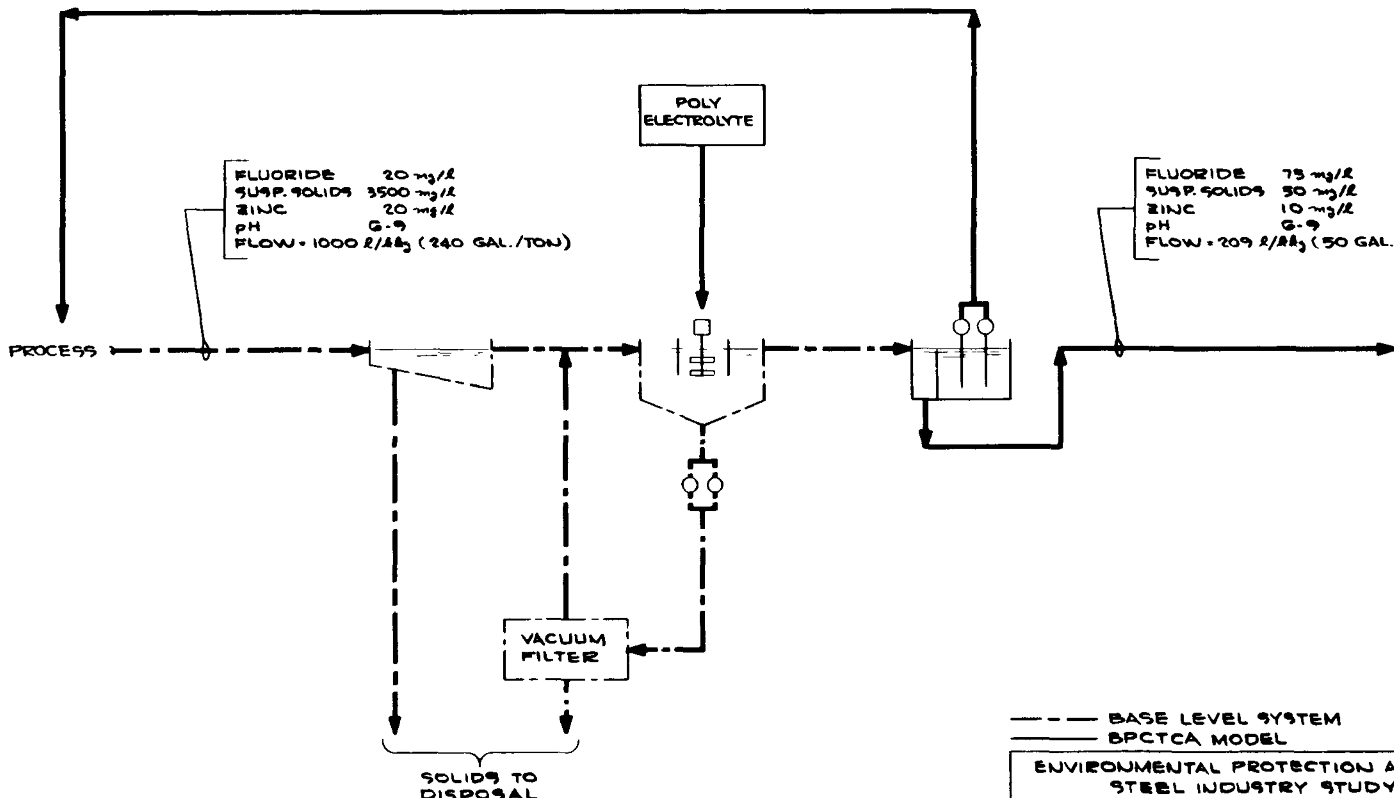
TABLE 74

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (LB/1000 LB) (1)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED TOTAL COST (4) $/KKg	$/TON
Suspended Solids	0.0104	50	Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blowdown to control cycles of concentration	0.083	.0753
pH	6.0-9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton) (excluding all non contact cooling water)				

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



— - — BASE LEVEL SYSTEM
——— BPCTCA MODEL

ENVIRONMENTAL PROTECTION AGENCY STEEL INDUSTRY STUDY ELECTRIC ARC FURNACE (WET) SUBCATEGORY BPCTCA MODEL	
11-15-73	FIGURE G9

regulated the furnace gas cooling water spray system so that only a wetted sludge was discharged to the drag tank for subsequent disposal. The recommended BPCTCA limitation for semi-wet systems has therefore been recommended to be "no discharge of process waste water pollutants to navigable waters." Both plants surveyed are currently achieving this limitation.

The two wet systems surveyed had similar wastewater treatment systems. These plants were recycling untreated wastes at the rates of 12,906 and 12,010 l/kkg (3,095 and 2,880 gal/ton) of product respectively. The two plants were treating their blowdown streams which were being discharged at the rates of 1,268 and 659 l/kkg (304 and 158 gal/ton), respectively. The recycle rates are inadequate, i.e. excessive, in that the electric arc furnace wet gas cleaning system should be able to operate on the same recycle flows as the BOF and open hearth furnace systems. The average recycle rate on the five BOF (wet) and open hearth furnaces surveyed was found to be 2,756 l/kkg (661 gal/ton). Further the systems should be able to achieve blowdown rates equivalent to 7.5% of this recycle rate or 209 l/kkg (50 gal/ton). Since these systems can be made essentially identical to the BOF and open hearth recycle systems for gas scrubbing, the BPCTCA limitations were established on the basis of effluent flows of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutants parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The two plants surveyed were achieving suspended solids concentrations of 58 and 23 mg/l in the treated blowdowns. Since the use of properly designed and operated clarifiers, and/or chemical, and/or magnetic flocculation can readily achieve suspended solids concentrations on this type of waste of less than 50 mg/l, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l in an effluent flow of 209 l/kkg (50 gal/ton). The two surveyed plants are currently achieving lower concentrations on the average, although the limitation load is being exceeded due to the excessive blowdown rates.

pH

The two plants surveyed were both discharging effluents at a pH of 7.9. This is well within the BPCTCA permissible pH range recommendation of 6.0 to 9.0.

Vacuum Degassing Subcategory

The direct contact process water used in vacuum degassing is the cooling water used for the steam-jet ejector barometric condensers. All vacuum systems draw their vacuum through the use of steam ejectors. As the water rate depends upon the steaming rate and the number of stages used

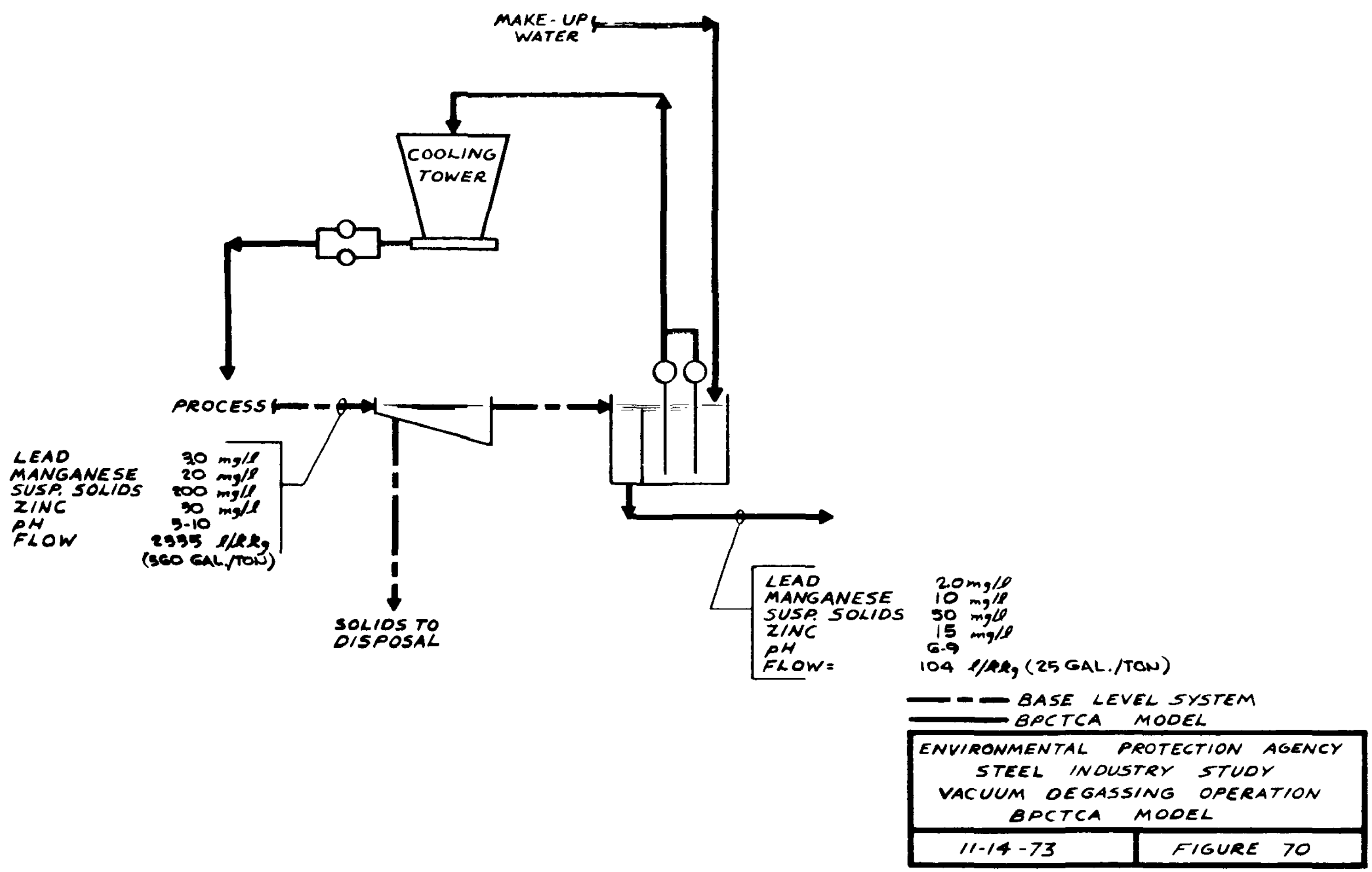
TABLE 75

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Vacuum Degassing

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0052	50	Settling with coagulation; tight recycle with minimal blowdown; filtration and cooling over a cooling tower for entire recycle flow	0.568	0.516
pH	6.0-9.0				
Flow	Most probable value for tight system is 104 liters effluent per kkg of steel degassed (25 gal/ton) (excluding all non contact cooling water)				

(1) Kilograms per metric ton of steel degassed or pounds per 1000 pounds of steel degassed.
(2) Milligrams per liter based on 104 liters effluent per kkg of steel degassed (25 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



MAKE-UP WATER
COOLING TOWER
PROCESS
LEAD 30 mg/l
MANGANESE 20 mg/l
SUSP. SOLIDS 200 mg/l
ZINC 30 mg/l
pH 5-10
FLOW 2335 l/kkg (560 GAL./TON)
SOLIDS TO DISPOSAL
LEAD 20 mg/l
MANGANESE 10 mg/l
SUSP. SOLIDS 50 mg/l
ZINC 15 mg/l
pH 6-9
FLOW= 104 l/kkg (25 GAL./TON)
BASE LEVEL SYSTEM
BPCTCA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSING OPERATION
BPCTCA MODEL
11-14-73
FIGURE 70

in the steam ejector, the process flow rates can vary considerably. Two degassing plants were surveyed and each had a waste water treatment system which treated other steelmaking operation process waste waters as well; i.e. one with a continuous casting water treatment system and the other with BOF discharges. The water systems were recirculating with blowdown. The blowdown rates varied from 58 to 67 l/kkg (14 to 16 gal/ton) and represented from 2% to 5% of the process recycle rate, respectively. The BPCTCA limitations were established on the basis of an effluent flow of 104 l/kkg (25 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. The value of 104 l/kkg (25 gal/ton) has been set slightly above the measured values to provide a margin of safety in the interpretation of the data from the two rather complex joint treatment facilities studied.

A review of the data collected resulted in the following effluent guidelines:

Suspended Solids

For the two plants surveyed, the suspended solids in the final effluent were found to be 37 and 1077 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for suspended solids removal, since the waste waters were being recycled without treatment and the blowdown was being discharged without treatment. The plant achieving the suspended solids level of 37 mg/l was using high rate pressure sand filtration on the final effluent prior to discharge. The BPCTCA limitation for suspended solids is based on 50 mg/l in 104 l/kkg (25 gal/ton) of product. An alternate technology for removal of these critical parameters to the indicated levels would be coagulation techniques. Table 75 is referred to for a summary of indicated BPCTCA limitations and suggested technologies.

pH

The pH of the two plants surveyed was found to vary between 6.2 and 7.7 which is within the recommended BPCTCA permissible range for pH of 6.0 to 9.0.

Continuous Casting Subcategory

The only process waters used in the continuous casting operation are direct contact cooling water sprays which cool the cast product as it emerges from the molds. The water treatment methods used are either recycle flat bed filtration for removal of suspended solids and oils or scale pits with recirculating pumps. Both systems require blowdown. The flat bed filters remove oil and suspended solids whereas the scale pits may require ancilliary oil removal devices.

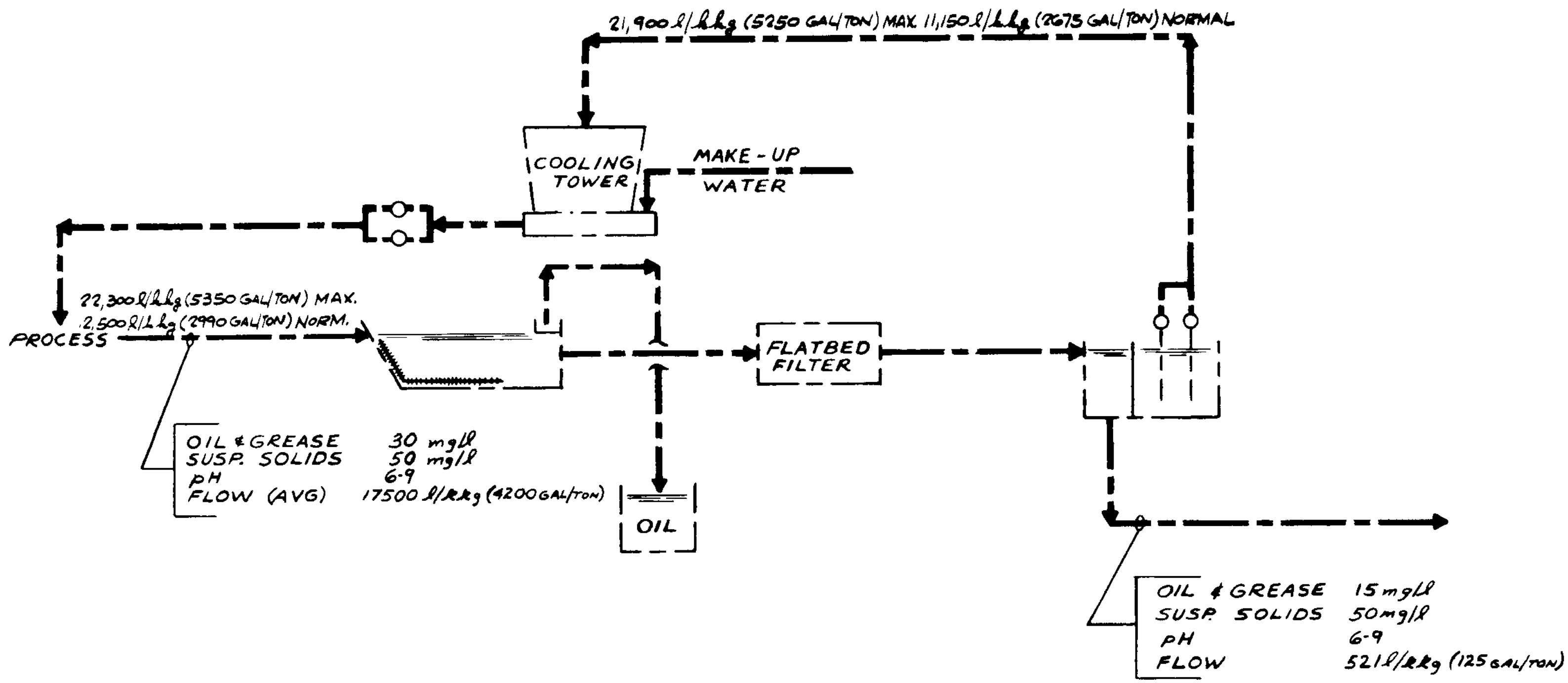
TABLE 76

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Continuous Casting

CRITICAL PARAMETERS	BPCTCA LIMITATIONS Kg/KKg(1) (LB/1000 LB)	mg/l(2)	CONTROL & TREATMENT TECHNOLOGY(3)	ESTIMATED(4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0260	50	Scale pit with dragout conveyor	Zero (0)	
Oil and Grease	0.0078	15	Oil skimmer		
			Flatbed filtration		
			Recycle loop with blowdown and cooling tower		
pH	6.0-9.0				
Flow	Most probable value for tight system is 522 liters effluent per kkg of steel cast (125 gal/ton)(excluding all non contact cooling water)				

(1) Kilograms per metric ton of steel cast, or pounds per 1000 pounds of steel cast.
(2) Milligrams per liter based on 522 liters effluent per kkg of steel cast (125 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.



— — — BASE LEVEL SYSTEM

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
CONTINUOUS CASTING SUBCATEGORY
BPCTCA MODEL

11-13-73 | FIGURE 71

Two continuous casting plants were surveyed. One plant had a scale pit with sand filters with blowdown while the other plant had flat bed filters with blowdown. Both had cooling towers for cooling the spray water before recycling to the caster. The blowdown varied between 342 and 463 l/kkg (82 and 111 gal/ton). The BPCTCA limitations were therefore established on the basis of an effluent flow of 521 l/kkg (125 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The plant employing the flat bed filter system was achieving 4.4 mg/l suspended solids in the treated effluent; whereas the plant utilizing the pressure sand filters was obtaining only 37 mg/l in the final treated effluent. An apparent anomaly existed here, since deep bed sand filters normally achieve higher quality effluents than flat bed filters. It was later discovered that the plant using the pressure sand filters was continually backwashing one of the dirty filters into the final treated effluent. This plant was judged inadequate with respect to applying good engineering design to alleviate the problem of contaminating the treated effluent with filter backwash. By correcting this problem, this plant should have no trouble obtaining low concentrations of suspended solids in the filtrate. To be consistent with the BPCTCA limitations for suspended solids which has been established for most of the other subcategories, however, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 521 l/kkg (125 gal/ton). Both plants surveyed are currently operating well within this load limitation.

Oil and Grease

The two plants surveyed were achieving excellent reductions in oil and grease as an apparent result of removal in the filtering devices. The two plants combined averaged less than 2.4 mg/l oil in the final effluent. However, to be consistent with the reasoning presented under Coke Making-By Product the BPCTCA limitation for oil and grease has been established on the basis of 15 mg/l at 521 l/kkg (125 gal/ton). Table 76 summarizes the indicated technology.

pH

The pH for the two plants surveyed varied bewteen 6.8 and 7.7 which is well within the recommended BPCTCA permissible range for pH of 6.0 to 9.0.

Treatment Models

Treatment models of systems to achieve the effluent quality proposed for each subcategory have been developed. Sketches of the BPCTCA models are presented in Figures 60 through 72A1. The development included not only a determination that a treatment facility of the type developed for each subcategory could achieve the effluent quality proposed but it included a determination of the capital investment and the total annual operating costs for the average size facility. In all subcategories these models are based on the combination of unit (waste treatment) operations in an "add-on" fashion as required to control the significant waste parameters. The unit operations were each selected as the least expensive means to accomplish their particular function and thus their combination into a treatment model presents the least expensive method of control for a given subcategory.

Alternate treatment methods could be only low insignificantly more effective and would be more expensive. In only one subcategory, the By Product Coke Subcategory, was an alternate developed to provide an option for a high capital investment and high operating cost biological system (as compared to the low capital investment and low operating cost physical-chemical system) to achieve the BPCTCA limitation for 1977. This alternate was developed because the multistage biological system, which would be an add-on to the BPCTCA single stage biosystem, is the most economical way to achieve the BATEA limitations for 1983.

However, to achieve the BATEA limitations the alternate relies on the use of treatment technology that has been developed only to the pilot stage or as steps utilized individually, but not in the combination required in this model on this type of waste on a full scale basis. The effluent limitations have been established such that either alternate can achieve the effluent qualities on which the BPCTCA and BATEA limitations are based.

A cost analysis indicates that the limitations on by product coke operations can most economically be achieved by applying alternate I to achieve BPCTCA and alternate II to achieve BATEA. Costs were therefore developed on the basis of depreciation of the BPCTCA system in 6 years (1977 - 1983). This not only saves enough on annual operating costs from the present to 1983 to more than offset the increased capital cost incurred in converting from one control technology to the other in 1983 (switching from physical/chemical to biological means of control), but it also minimizes the total costs during the interim period while other possible alternates are evaluated and allows for flexibility in the event that BATEA limitations are later revised to lower values or to no discharge of process waste water pollutants to navigable waters.

Cost Effectiveness Diagrams

Figures 72B through 83B presented in Section X show the pollutant reduction achieved by each step of the treatment models discussed in Tables 54 through 64 and the cumulative cost, including base level, to achieve that reduction. The curves are discussed in more detail in Section X.

SECTION X

EFFLUENT QUALITY ATTAINABLE THROUGH
THE APPLICATION OF THE BEST AVAILABLE
TECHNOLOGY ECONOMICALLY ACHIEVABLE

EFFLUENT LIMITATIONS GUIDELINES

Introduction

The effluent limitations which must be achieved by July 1, 1983 are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. Best available technology is not based upon an average of the best performance within an industrial category, but is to be determined by identifying the very best control and treatment technology employed by a specific point source within the industrial category or subcategory, or where it is readily transferable from one industry to another, such technology may be identified as BATEA technology. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

a. the size and age of equipment and facilities involved

b. the processes employed

c. nonwater quality environmental impact (including energy requirements)

d. the engineering aspects of the application of various types of control techniques

e. process changes

f. the cost of achieving the effluent reduction resulting from application of BATEA technology

Best available technology assesses the availability in all cases of in-process changes or controls which can be applied to reduce waste loads as well as additional treatment techniques which can be applied at the end of a production process. Those plant processes and control technologies which at the pilot plant, semi-works, or other level, have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities may be considered in assessing best available technology.

Best available technology is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants. Although economic factors are considered in this development, the costs for this level of control is intended to be the top-of-the-line current technology subject to limitations imposed by economic and engineering feasibility. However, this level may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, the BATEA limitations may necessitate some industrially sponsored development work prior to its application.

Rationale for the Selection of BATEA

The following paragraphs summarize the factors that were considered in selecting the categorization, water use rates, level of treatment technology, effluent concentrations attainable by the technology, and hence the establishment of the effluent limitations for BATEA.

Size and Age of Facilities and Land Availability Considerations:

As discussed in Section IV, the age and size of steel industry facilities has little direct bearing on the quantity or quality of waste water generated. Thus, the ELG for a given subcategory of waste source applies equally to all plants regardless of size or age. Land availability for installation of add-on treatment facilities can influence the type of technology utilized to meet the ELG's. This is one of the considerations which can account for a range in the costs that might be incurred.

Consideration of Processes Employed:

All plants in a given subcategory use the same or similar production methods, giving similar discharges. There is no evidence that operation of any current process or subprocess will substantially affect capabilities to implement the best available control technology economically achievable. At such time that new processes, such as direct reduction, appear imminent for broad application the ELG's should be amended to cover these new sources. No process changes are envisioned for implementation of this technology for plants in any subcategory except Coke Making-By Product where the installation of a recycle system will be required on the barometric condenser system in order to achieve 417 l/kkg (100 gal/ton) of product on which the ELGs are based. The treatment technologies to achieve BATEA assesses the availability of in-process controls as well as control or additional treatment techniques employed at the end of a production process.

Consideration of Nonwater Quality Environmental Impact:

Impact of Proposed Limitations on Air Quantity:

The impact of BATEA limitaitons upon the non-water elements of the environment has been considered. The increased use of recycle systems and stripping columns have the potential for increasing the loss of volatiles to the atmosphere. Recycle systems are so effective in reducing waste water volumes and hence waste loads to and from treatment systems and in reducing the size and cost of treatment systems that a tradeoff must be accepted. Recycle systems requiring the use of cooling towers have contributed significantly to reductions of effluent loads while contributing only minimally to air pollution problems. Stripper vapors have been successfully recovered as usable by products or can be routed to incinerators. Careful operation of either system can avoid or minimize air pollution problems.

Impact of Proposed Limitations on Solid Waste Problems:

Consideration has also been given to the solid waste aspects of water pollution controls. The processes for treating the waste waters from this industry produce considerable volumes of sludges. Much of this material is inert iron oxide which can be reused profitably. Other sludges not suitable for reuse must be disposed of to landfills since most of it is chemical precipitates which could be little reduced by incineration. Being precipitates they are by nature relatively insoluble and nonhazardous substances requiring minimal custodial care.

Impact of Proposed Limitations due to Hazardous Materials:

In order to ensure long-term protection of the environment from harmful constituents, special consideration of disposal sites should be made. All landfill sites should be selected so as to prevent horizontal and vertical migration of these contaminants to ground or surface waters. In cases where geologic conditions may not reasonably ensure this, adequate mechanical precautions (e.g., impervious liners) should be taken to ensure long-term protection to the environment. A program of routine periodic sampling and analysis of leachates is advisable. Where appropriate the location of solid hazardous materials disposal sites, if any, should be permanently recorded in the appropriate office of legal jurisdiction.

Impact of Proposed Limitations on Energy Requirements:

The effects of water pollution control measures on energy requirements has also been determined. The additional energy required in the form of electric power to achieve the effluent limitations proposed for BPCTCA and BATEA amounts to less than 1.5% of the electrical energy used by the steel industry in 1972.

The enhancement to water quality management provided by these proposed effluent limitations substantially outweighs the impact on air, solid waste, and energy requirements.

Consideration of the Engineering Aspects of the Application of Various Types of Control Techniques:

This level of technology is considered to be the best available and economically achievable in that the concepts are proven and available for implementation and may be readily applied through adaptation or as add-ons to proposed BPCTCA treatment facilities.

Consideration of Process Changes:

No process changes are envisioned for implementation of this technology for plants in any subcategory except By Product Coke where the installation of a recycle system on the barometric condensers may be the most feasible means to achieve the 417 l/kkg (100 gal/ton) flow on which the ELGs are based. The treatment technologies to achieve BATEA assesses the availability of in-process controls as well as control or additional treatment techniques employed at the end of a production process.

Consideration of Costs of Achieving the Effluent Reduction Resulting from the Application of BATEA Technology:

The costs of implementing the BATEA limitations relative to the benefits to be derived is pertinent but is expected to be higher per unit reduction in waste load achieved as higher quality effluents are produced. The overall impact of capital and operating costs relative to the value of the products produced and gross revenues generated was considered in establishing the BATEA limitations.

The technology evaluation, treatment facility costing, and calculation of overall capital and operating costs, to the industry as described in Section IX and which provided the basis for the development of the BPCTCA limitations was also used to provide the basis for determining the BATEA limitations, the costs therefore, and the acceptability of those costs.

The initial capital investment and total annual expenditures required of the industry to achieve BATEA limitations are summarized in Table 89.

After selection of the treatment technology to be designated as one means to achieve the BATEA limitations for each subcategory was made, a sketch of each treatment model was prepared. The sketch for each subcategory is presented following the tables presenting the BATEA limitations for the subcategory.

Identification of the Best Available Technology Economically Achievable - BATEA

Based on the information contained in Sections III through VIII of this report, a determination has been made that the quality of effluent attainable trhough the application of the Best Available Technology Economically Achievable is as listed in Tables 77 through 88. These tables set forth the ELG's for the following subcategories of the steel industry:

- I - By Product Coke Subcategory
- II - Beehive Coke Subcategory
- III - Sintering Subcategory
- IV - Blast Furnace (Iron) Subcategory
- V - Blast Furnace (Ferromanganese) Subcategory
- VI - Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory
- VII - Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory
- VIII - Open Hearth Furnace Subcategory
- IX - Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory
- X - Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory
- XI - Vacuum Degassing Subcategory
- XII - Continuous Casting Subcategory

ELG's have not been set for Pelletizing and Briquetting operations because plants of this type were not found to be operating as an integral part of any integrated steel mill. These operations will be considered in mining regulations to be proposed at a later date since they are normally operated in conjunction with mining operations.

In establishing the subject guidelines, it should be noted that the resulting limitations or standards are applicable to aqueous waste discharges only, exclusive of non-contact cooling waters. In the section of this report which discusses control and treatment technology for the iron and steelmaking industry as a whole, a qualitative reference has been given regarding "the environmental impact other than water" for the subcategories investigated.

The effluent guidelines established herein take into account only those aqueous constituents considered to be major pollutants in each of the subcategories investigated. In general, the critical parameters were selected for each subcategory on the basis of those waste constituents known to be generated in the specific manufacturing process and also known to be present in sufficient quantity to be inimical to the environment. Certain general parameters such as suspended solids naturally include the oxides of iron and silica, however, these later specific constituents were not included as critical parameters, since adequate removal of the general parameter (suspended solids) in turn provides for adequate removal of the more specific parameters indicated. This does not hold true when certain of the parameters are in the dissolved state; however, in the case of iron oxides generated in the iron and steelmaking processes, they are for the most part insoluble in the relatively neutral effluents in which they are contained. The absence of apparent less important parameters from the guidelines in no way endorses unrestricted discharge of same.

The recommended effluent limitations guidelines resulting from this study for BATEA limitations are summarized in Tables 77 to 88. These tables also list the control and treatment technology applicable or normally utilized to reach the constituent levels indicated. These effluent limitations set herein are by no means the absolute lowest values attainable (except where no discharge of process waste water pollutants to navigable waters is recommended) by the indicated technology, but moreover they represent values which can be readily <u>controlled</u> <u>around</u> on a day by day basis.

It should be noted that these effluent limitations represent values not to be exceeded by any 30 continuous day average. The maximum daily effluent loads per unit of production should not exceed these values by a factor of two as discussed in Section IX.

Cost vs Effluent Reduction Benefits:

Estimated total costs on a dollars per ton basis have been included for each subcategory as a whole. These costs have been based on the wastewaters emanating from a typical average size production facility for each of the subcategories investigated. In arriving at these effluent limitations guidelines, due consideration was given to keeping the costs of implementing the new technology to a minimum. Specifically, the effluent limitation guidelines were kept at values which would not result in excessive capital or operating costs to the industry. The capital and annual operating costs that would be required of the industry to achieve BATEA was determined by a six step process for each of the twelve subcategories. It was first determined what treatment processes were already in place and currently being utilized by most of the plants. Secondly, a hypothetical treatment system was envisioned which, as an add-on to existing facilities would treat the effluent sufficiently to meet BATEA ELG's. Thirdly, the average plant size was determined by dividing the total industry production by the number of operating facilities. Fourth, a quasi-detailed engineering estimate was prepared on the cost of the components and the total capital cost of the add-on facilities for the average plant. Fifth, the annual operating, maintenance, capital recovery (basis 10 years straight line depreciation) and capital use (basis 7% interest) charges were determined. And sixth, the costs developed for the average facility were multiplied by the total number of facilities to arrive at the total capital and annual costs to the industry for each subcategory. The results are summarized in Table 89.

BATEA Effluent Limitations Guidelines

The BATEA limitations have been established in accordance with the policies and definitions set forth at the beginning of this section. Further refinements of some of the technologies and the ELGs discussed in the previous Section IX of this study will be required. The subject BATEA limitations are summarized in Tables 77 to 88 along with their projected costs and treatment technologies.

Discussion By Subcategories:

Plants in the beehive, and electric furnace semi-wet subcategories are presently achieving the effluent qualities that are specified herein. No plants in the other subcategories are presently achieving the total effluent quality proposed. However, each of the control techniques is presently employed at individual plants or in other industries and are considered to be technologies that are transferable to the treatment of steel industry wastes.

The rationale used for developing BATEA effluent limitations guidelines is summarized below for each of the major subcategories. All effluent limitations guidelines are presented on a "gross" basis since for the most part, removals are relatively independent of initial concentrations of contaminants. The ELGs are in kilograms of pollutant per metric ton of product or in pounds of pollutant per thousand pounds of product and in these terms only. The ELG's are not a limitation on flow, type of technology to be utilized, or concentrations to be achieved. These items are listed only to show the basis for the ELG's and may be varied as the discharger desires so long as the ELG's per unit of production are met.

By Product Coke Subcategory

Following is a summary of the factors used to establish the effluent limitation guidelines applying to coke making by-product. As far as possible, the stated limits are based upon performance levels attained by the coke plants surveyed during this study. Where treatment levels can be improved by application of additional currently available control and treatment technology, the anticipated reduction of waste loads was included in the estimates. Flows at three of the four by product coke

TABLE 77

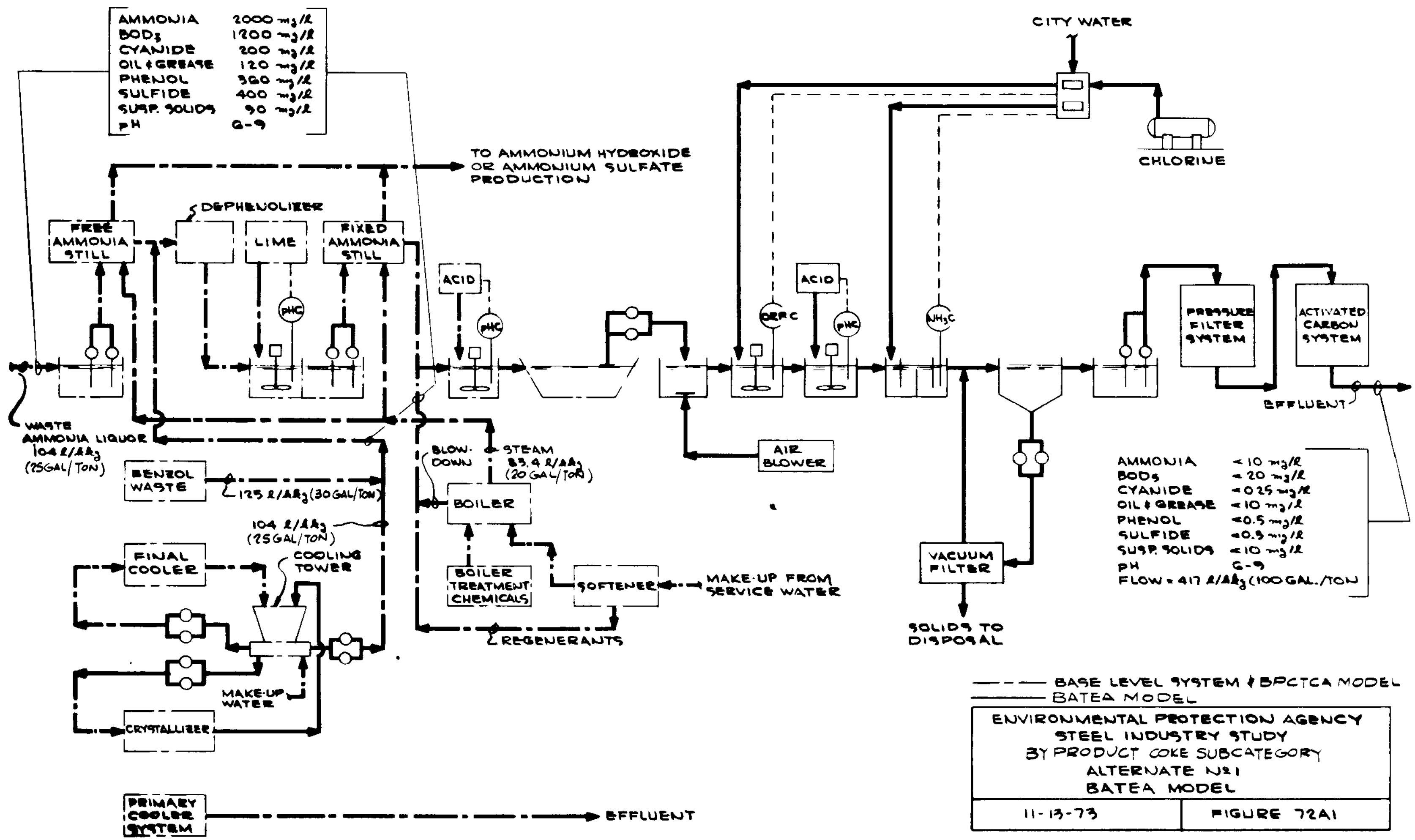
BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY By Product Coke

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BATEA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
*Cyanide$_A$	0.00010	0.25	BPCTCA plus:		
Phenol	0.00021	0.5	Recycle crystallizer effluent to final cooler recycle system		
Ammonia (as NH_3)	0.0042	10	Sulfide oxidation (aeration)		
BOD_5	0.0083	20	Clarification	0.405	0.367
Sulfide	0.00012	0.3	Abandon dephenolization		
Oil and Grease	0.0042	10	Multi-stage biological oxidation with methanol addition		
Suspended Soilids	0.0042	10	Pressure filtration		
pH	6.0-9.0				
Flow	Most probable value for tight system is 417 liters effluent per kkg of coke produced (100 gal/ton) (excluding all non contact cooling water)				

(1) Kilograms per metric ton of coke produced, or pounds per 1000 pounds of coke produced.
(2) Milligrams per liter based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

*Cyanides amenable to chlorination. Reference ASTM D 2036-72 Method B.


AMMONIA 2000 mg/l
BOD5 1200 mg/l
CYANIDE 200 mg/l
OIL & GREASE 120 mg/l
PHENOL 360 mg/l
SULFIDE 400 mg/l
SUSP. SOLIDS 90 mg/l
pH 6-9
TO AMMONIUM HYDROXIDE OR AMMONIUM SULFATE PRODUCTION
FREE AMMONIA STILL
DEPHENOLIZER
LIME
FIXED AMMONIA STILL
pHC
ACID
CITY WATER
CHLORINE
ORP C
NH3C
PRESSURE FILTER SYSTEM
ACTIVATED CARBON SYSTEM
EFFLUENT
WASTE AMMONIA LIQUOR 104 l/kkg (25 GAL/TON)
BENZOL WASTE
125 l/kkg (30 GAL/TON)
104 l/kkg (25 GAL/TON)
COOLING TOWER
FINAL COOLER
MAKE-UP WATER
CRYSTALLIZER
BLOW-DOWN
STEAM 83.4 l/kkg (20 GAL/TON)
BOILER
BOILER TREATMENT CHEMICALS
SOFTENER
MAKE-UP FROM SERVICE WATER
REGENERANTS
AIR BLOWER
VACUUM FILTER
SOLIDS TO DISPOSAL
AMMONIA <10 mg/l
BOD5 <20 mg/l
CYANIDE <0.25 mg/l
OIL & GREASE <10 mg/l
PHENOL <0.5 mg/l
SULFIDE <0.3 mg/l
SUSP. SOLIDS <10 mg/l
pH 6-9
FLOW = 417 l/kkg (100 GAL./TON)
PRIMARY COOLER SYSTEM
EFFLUENT
BASE LEVEL SYSTEM & BPCTCA MODEL
BATEA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY PRODUCT COKE SUBCATEGORY
ALTERNATE No 1
BATEA MODEL
11-13-73
FIGURE 72A1

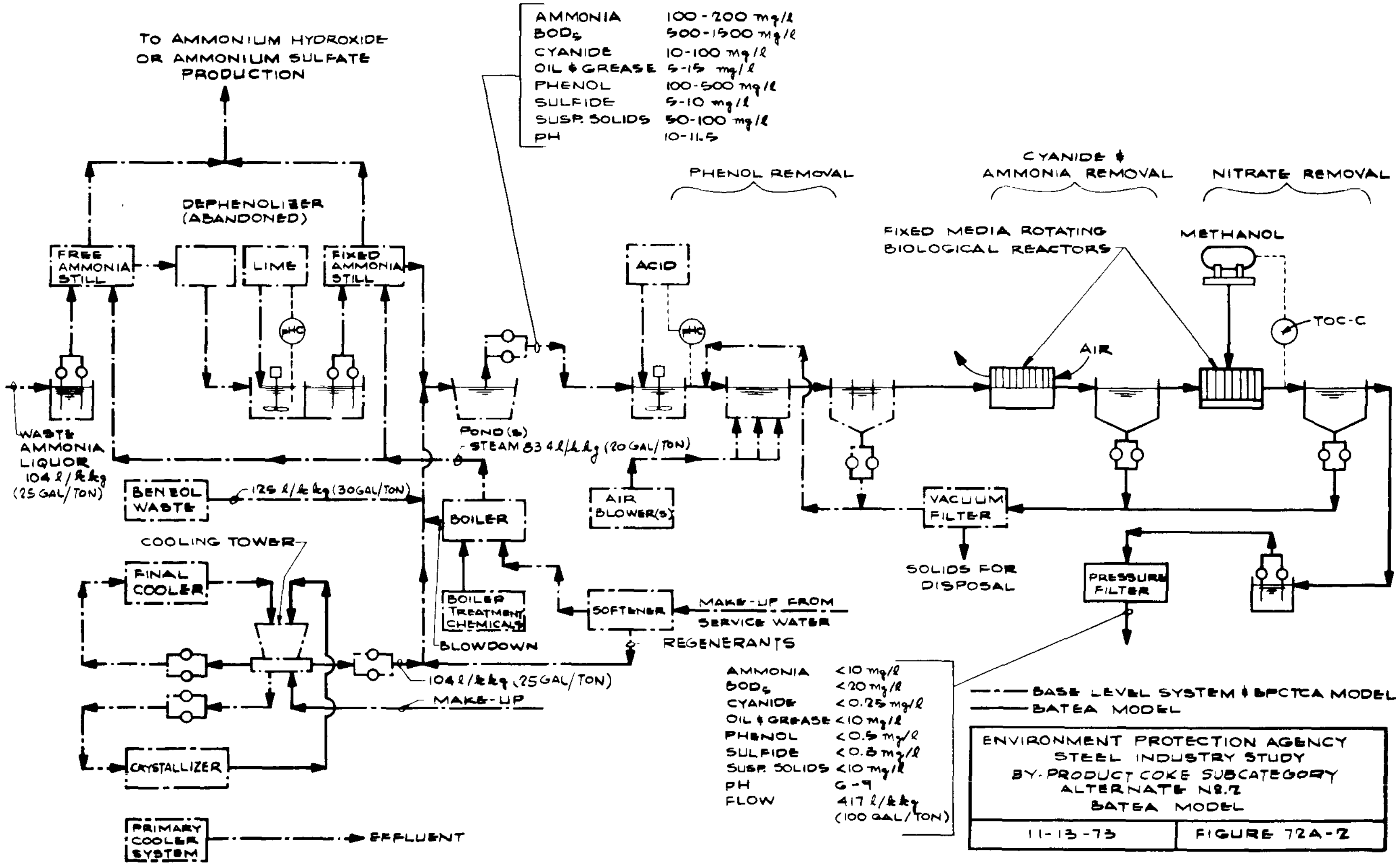

TO AMMONIUM HYDROXIDE OR AMMONIUM SULFATE PRODUCTION
AMMONIA 100-200 mg/l
BOD5 500-1500 mg/l
CYANIDE 10-100 mg/l
OIL & GREASE 5-15 mg/l
PHENOL 100-500 mg/l
SULFIDE 5-10 mg/l
SUSP. SOLIDS 50-100 mg/l
PH 10-11.5
PHENOL REMOVAL
CYANIDE & AMMONIA REMOVAL
NITRATE REMOVAL
DEPHENOLIZER (ABANDONED)
FREE AMMONIA STILL
LIME
FIXED AMMONIA STILL
ACID
FIXED MEDIA ROTATING BIOLOGICAL REACTORS
METHANOL
TOC-C
AIR
WASTE AMMONIA LIQUOR 104 l/kkg (25 GAL/TON)
POND(S)
STEAM 83.4 l/kkg (20 GAL/TON)
BENZOL WASTE
125 l/kkg (30 GAL/TON)
BOILER
AIR BLOWER(S)
VACUUM FILTER
SOLIDS FOR DISPOSAL
PRESSURE FILTER
COOLING TOWER
FINAL COOLER
BOILER TREATMENT CHEMICALS
BLOWDOWN
SOFTENER
MAKE-UP FROM SERVICE WATER
REGENERANTS
104 l/kkg (25 GAL/TON)
MAKE-UP
CRYSTALLIZER
PRIMARY COOLER SYSTEM
EFFLUENT
AMMONIA <10 mg/l
BOD5 <20 mg/l
CYANIDE <0.25 mg/l
OIL & GREASE <10 mg/l
PHENOL <0.5 mg/l
SULFIDE <0.8 mg/l
SUSP. SOLIDS <10 mg/l
PH 6-9
FLOW 417 l/kkg (100 GAL/TON)
BASE LEVEL SYSTEM & BPCTCA MODEL
BATEA MODEL
ENVIRONMENT PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE NO. 2
BATEA MODEL
11-13-73
FIGURE 72A-2

FIGURE 72B

MODEL COST EFFECTIVENESS DIAGRAM
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE II (BIOLOGICAL)

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 2414 KKG/DAY (2660 TON/DAY) COKE PLANT

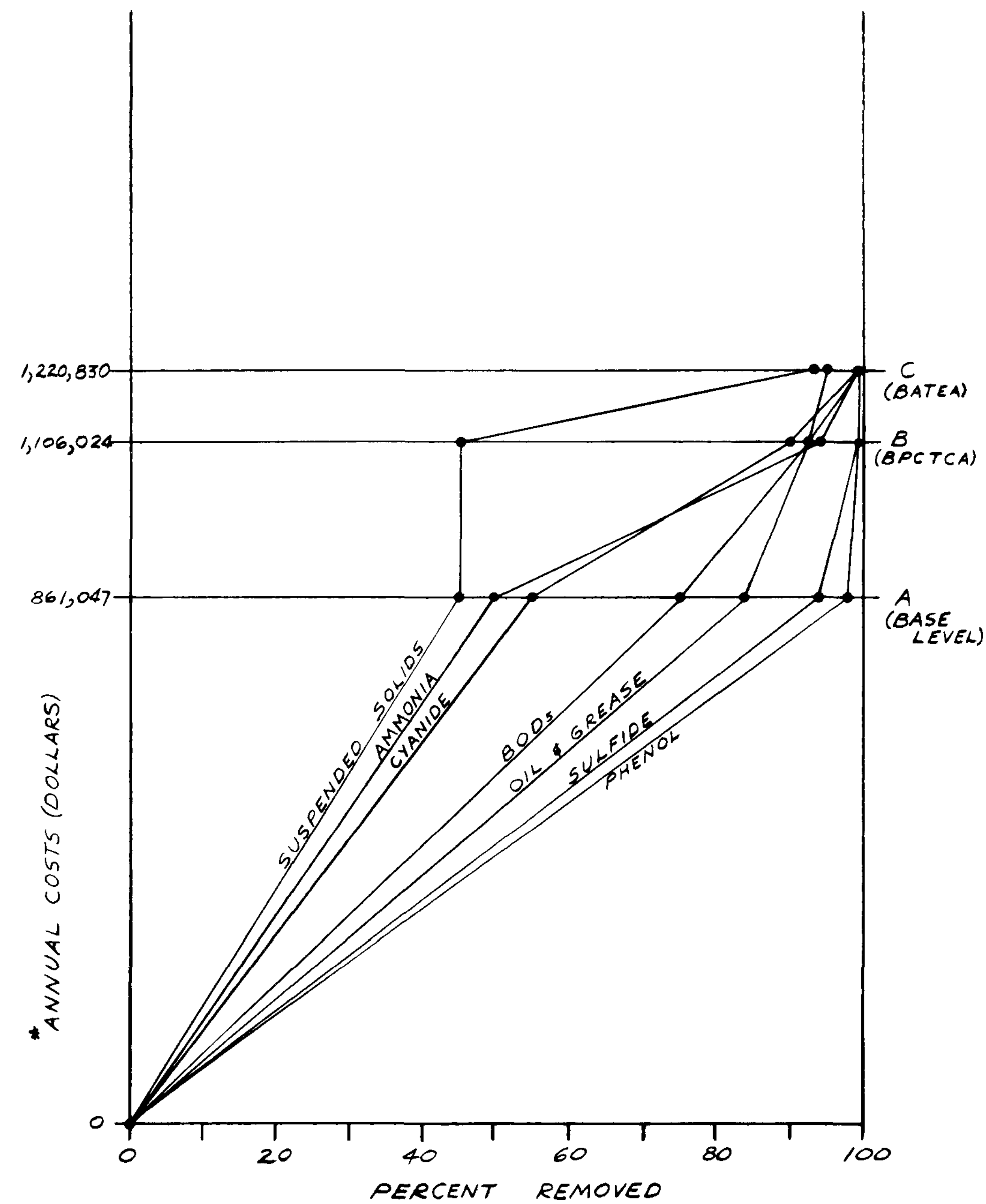
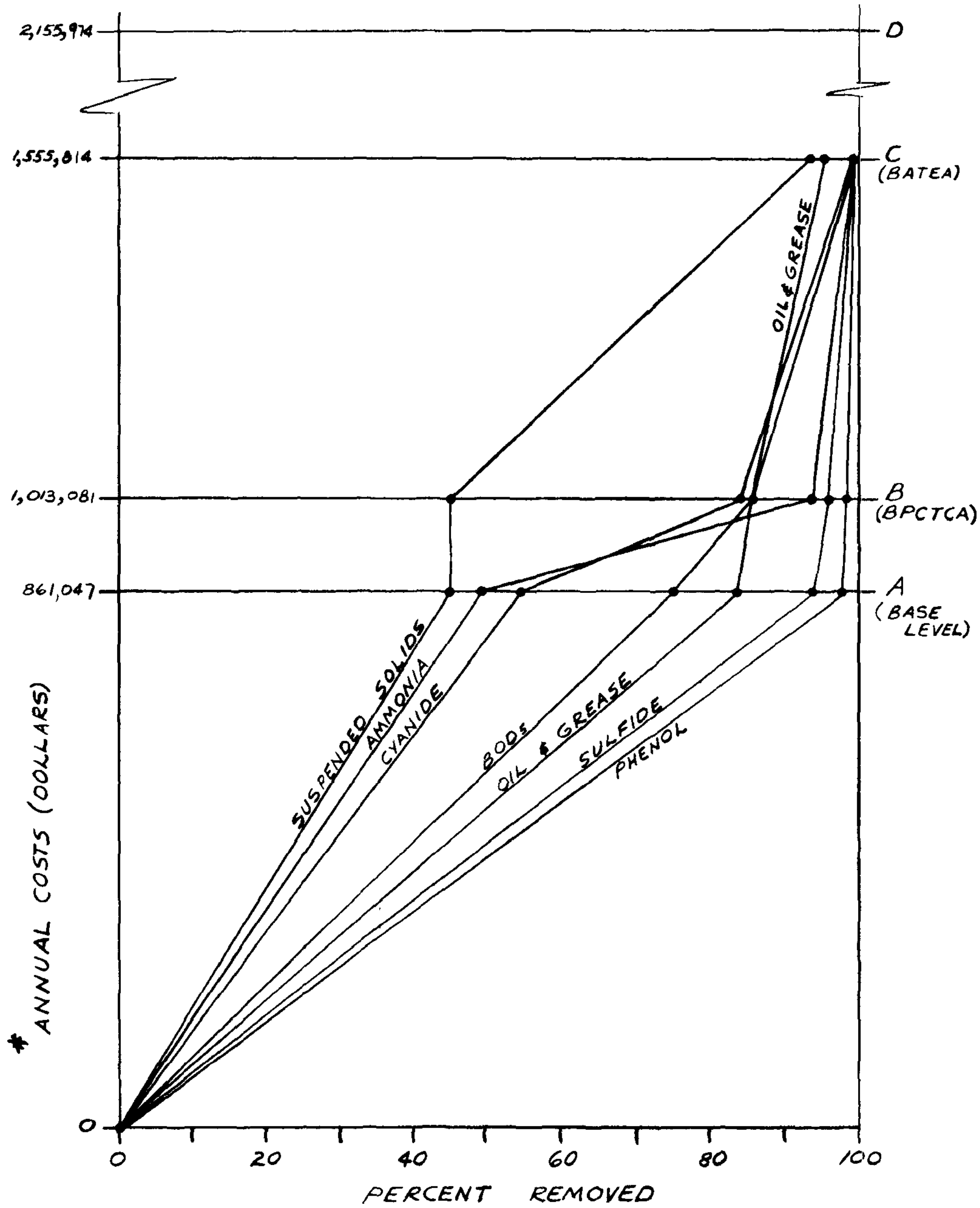


FIGURE 72 C

MODEL COST EFFECTIVENESS DIAGRAM
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE I - (PHYSICAL / CHEMICAL)

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 2414 KKG/DAY (2660 TON/DAY) COKE PLANT



plants surveyed together averaged 417 l/kkg (100 gal/ton) of coke produced. The fourth plant was diluting their effluent with contaminated final cooler water. Two of the four plants were disposing of a portion of their wastes in coke quenching. Even if this practice is disallowed, it can still be shown that the effluent can be reduced to 417 l/kkg (100 gal/ton) by employing internal recycle followed by minimal blowdown on such systems as the barometric condenser and final cooler waters. This is summarized as follows:

Waste ammonia liquor	104 l/kkg	25 gal/ton
Steam condensate	75 l/kkg	18 gal/ton
Benzol plant waste	125 l/kkg	30 gal/ton
Final cooler blowdown	84 l/kkg	20 gal/ton
Barometric condenser blowdown	29 l/kkg	5 gal/ton
TOTAL	417 l/kkg	100 gal/ton

The ELG's were therefore based on total effluent flows of 417 l/kkg (100 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies.

By-products plants operating vacuum carbonate type desulfurization equipment will generate an additional 104 l/kkg (25 gal/ton) of waste water as discussed previously in Section IX, under rationale for BPCTCA. The effluent flow from these plants would be 521 l/kkg (125 gal/ton) of coke produced, rather than the 417 l/kkg (100 gal/ton) shown above.

Phenol

The ELG is based on 0.5 mg/l at a 417 l/kkg (100 gal/ton) discharge flow rate. The one single stage biological treatment system sampled was achieving 0.0639 mg/l on the average. The plant is achieving this only on the diluted wastes and some of the wastes are not treated. The dilution is required at this facility to prevent ammonia from interfering with the biological activity. If the waste were first treated in free and fixed stills for ammonia removal as recommended herein, dilution would not be required for this purpose. The routing of all plant process waste waters through a proposed multistage biological treatment facility can be expected to reduce the phenol waste load to well within the ELG recommended. Pilot plant sized multi-stage systems have been tested on by products coke plant wastes, and additional testing and scale-up continues. Full scale operating single-stage plants have shown consistently excellent phenol removals to well within the proposed ELG. Physical/chemical treatment methods involve alkaline chlorination, followed by carbon adsorption. Both of these techniques involve transfer of technology, the former from a full scale operating blast furnace (iron) subcategory plant within the iron and steel industry and from the metal plating industry; the latter from full-scale waste water treatment plants in the petrochemical industry. Either of the alternate treatment methods can achieve the proposed BATEA limitations for phenols.

Cyanide

None of the plants surveyed were intentionally practicing cyanide removal, except for some small reduction coincidental to stripping, extraction and/or biological processes employed for ammonia and phenol removals. All resulting levels of total cyanide in the final treated effluent were found to be excessive due to uniformly inadequate application of treatment technology specific to cyanide removal. However, within the iron and steel industry, cyanide removal is practiced by at least one operating plant in the blast furnace (iron) subcategory, and by many plating and finishing plants which will be surveyed as part of the Phase II study of this industry. In addition, the nonferrous metals industry routinely performs treatment for cyanide destruction as part of their operations. For these reasons, the ELG for cyanides is set at 0.25 mg/l based on a total effluent flow of 413 l/kkg (100 gal/ton) of coke produced. This limit is currently achieved at operating plants outside the By Product Coke subcategory by physical/chemical treatment methods as described in the phenol discussion above. The biological treatment of cyanides will require development to improve on currently achievable cyanide levels from operating single-stage plants. A multi-stage biological treatment system, including a stage containing biomasses specifications for cyanide removal, appears capable of reaching the proposed BATEA limitation for by product coke plant wastes by the time these limitations become effective. The technologies for accomplishing this level of treatment are shown in Table 77.

Ammonia

Two of the four plants surveyed were practicing ammonia removal with free and fixed stills, however, the resulting effluents (without dilution) were 115 and 417 mg/l, respectively, with the latter plant judged to be inadequate with respect to the capability of this technology. Furthermore, it becomes apparent that improved removals of phenol and especially cyanide by the technologies indicated above will self result in reductions of ammonia in the final effluent. Therefore, because of the inter-relationships of treating for phenol and cyanide, ammonia, will as a side effect of these other treatments be further reduced to less than 10 mg/l. The ELG based on 10 mg/l at 417 l/kkg (100 gal/ton) is further supported by a preponderance of bench scale and pilot studies for the treatment technologies shown in Table 77. The biological treatment alternate will require additional development of the type described in the cyanide discussion above to insure compliance with the BATEA limitation for ammonia. Most ammonia removal will occur during stripping operations prior to bio-oxidation.

BOD_5

One of the plants surveyed was achieving an effluent BOD_5 of 5 mg/l, however, this was the particular plant utilizing an excess amount of final cooler water as a dilutant. The plant employing the biological system for phenol removal was achieving 23 mg/l BOD_5 in the final effluent even though the use of other treatment methods for reducing the other waste parameters (which contribute to BOD_5) were not being utilized. Knowing that the primary contributors to BOD_5 are phenol, ammonia, cyanide, and oil and grease, it can readily be deduced that the utilization of treatments for reductions of these constituents will in turn reduce the BOD_5 in like proportion. Having accomplished the removals of these BOD_5 contributors, a conservative engineering judgement for the remaining BOD_5 would be 20 mg/l. The ELG for BOD_5 is therefore based on 20 mg/l at discharge flows of 417 l/kkg (100 gal/ton) based on the inter-relationships of the known contributors and their proposed reduction. This proposed reduction can be further demonstrated on a chemical/mathematical basis by those skilled in the art of biological reactions.

Oil and Grease

Two of the four plants surveyed were achieving less than 3 mg/l O & G, however, the one plant was doing so by dilution with contaminated final cooler water. In view of the oxidation methods which will be required for removal of the other listed pollutants, the O & G will be reduced to <10 mg/l in the oxidizing environment proposed. Auxiliary control technologies may be utilized to achieve this level as indicated in Table 77. The ELG for oil and grease for BATEA has been based on 10 mg/l in consideration of the testing problems discussed in Section IX.

Sulfide

Only one of the four plants surveyed was achieving a substantial sulfide reduction to 0.26 mg/l and this was being accomplished concurrently with biological oxidation of phenols. Another plant was achieving 1.5 mg/l sulfide, but by dilution. Since sulfide represents an immediate oxygen demand upon the receiving stream, and since technology exists for effective and inexpensive oxidation of sulfides, the remaining plants surveyed were judged to be uniformly inadequate with respect to the application of treatment technology for sulfide reduction. Therefore, the ELG for sulfide was based on 0.3 mg/l at 417 l/kkg (100 gal/ton). These values are achievable by direct oxidation with air, chemicals or biological techniques. At least one of these indicated removal techniques will be employed for reduction of certain of the other listed by-product pollutants. An example of applying one of the possible transferred technology methods of sulfide reduction would be chlorination of raw sewage in transit through sewer lines which is regularly practiced to reduce sulfide to 0.3 mg/l and less. Reduction to the indicated ELG level is further substantiated by a proliferation of bench scale studies performed with the technologies indicated in Table 77.

Suspended Solids

None of the plants surveyed were achieving removal of suspended solids to 10 mg/l except the one using excess dilution water. Nevertheless, there is an abundance of engineering knowhow and experience that demonstrates that suspended solids can be reduced to 10 mg/l in a cost effective manner. Therefore, all plants were judged to be _uniformly inadequate_ with respect to the application of treatment technology for suspended solids removal. The ELG for total suspended solids was based at 10 mg/l at 417 l/kkg (100 gal/ton). Table 77 lists some of the available technologies for readily achieving this level.

_pH_

Three of the four plants surveyed fall within the pH constraint range of 6.0 to 9.0 thus providing a basis for establishing this range as the BPCTCA. Any plant falling outside this range can readily remedy the situation by applying appropriate neutralization procedures to his final effluent. No further tightening of the BPCTCA pH range is recommended at this time. The ELG for BATEA remains at pH 6.0 to 9.0, and is currently achieved by operating plants in this subcategory.

Beehive Coke Subcategory

Currently, two of the three selected beehive coke operations surveyed practice zero (0) aqueous discharge. The recommended BATEA guidelines are therefore no discharge of process waste water pollutants to navigable waters, as previously set for BPCTCA limits in this subcategory. The control and treatment technology required would include provision for an adequate settling basin, and a complete recycle of all water collected from the process back to the process, with fresh water make-up as required. The system reaches equilibrium with respect to critical parameters, but provision must be made for periodic removal of settled solids from the basin. Actual operating costs are modest. No problems are anticipated in implementing BATEA guidelines for the Beehive Coke subcategory.

Sintering Subcategory

The only direct contact process water used in the sintering plant is water used for cooling and scrubbing off gases from the sintering strand. As with steelmaking, there are wet and dry types of systems. The sintering strand generally has two (2) independent exhaust systems, the dedusting at discharge end of the machine and the combustion and exhaust system for the sinter bed. Each one of these systems can either be wet or dry as defined in the process flow diagrams types I, II, III, shown as Figures 6, 7, and 8 respectively.

Generally the sinter bed exhaust systems are dry precipitation systems with the dedusting exhaust systems split between wet and dry.

TABLE 78

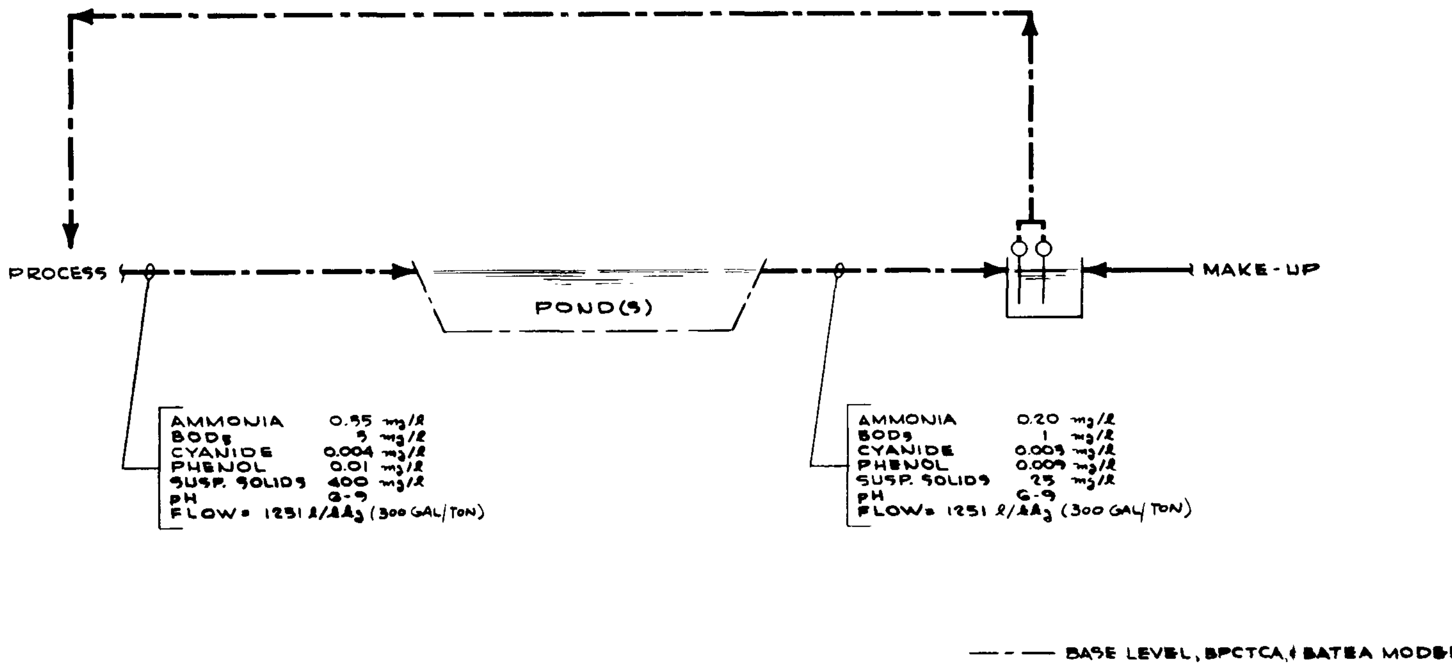
BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Beehive Coke

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB)	BATEA LIMITATIONS mg/l[2]	CONTROL & TREATMENT TECHNOLOGY[3]	ESTIMATED[4] TOTAL COST $/KKg	ESTIMATED[4] TOTAL COST $/TON
*Cyanide$_A$	No discharge of process wastewater pollutants to navigable waters (excluding all non-contact cooling water)		Same as BPCTCA		Zero (0)
Phenol					
Ammonia (as NH_3)					
BOD_5					
Sulfide					
Oil and Grease					
Suspended Solids					
pH					
Flow					

(1) Kilograms per metric ton of coke produced, or pounds per 1000 pounds of coke produced.
(2) Milligrams per liter based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination. Reference ASTM D 2036-72 Method B.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE SUBCATEGORY
BATEA MODEL

11-13-75	FIGURE 73A

FIGURE 73B

MODEL COST EFFECTIVENESS DIAGRAM
BEEHIVE COKE SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 665 KKG/DAY (730 TON/DAY) COKE PLANT

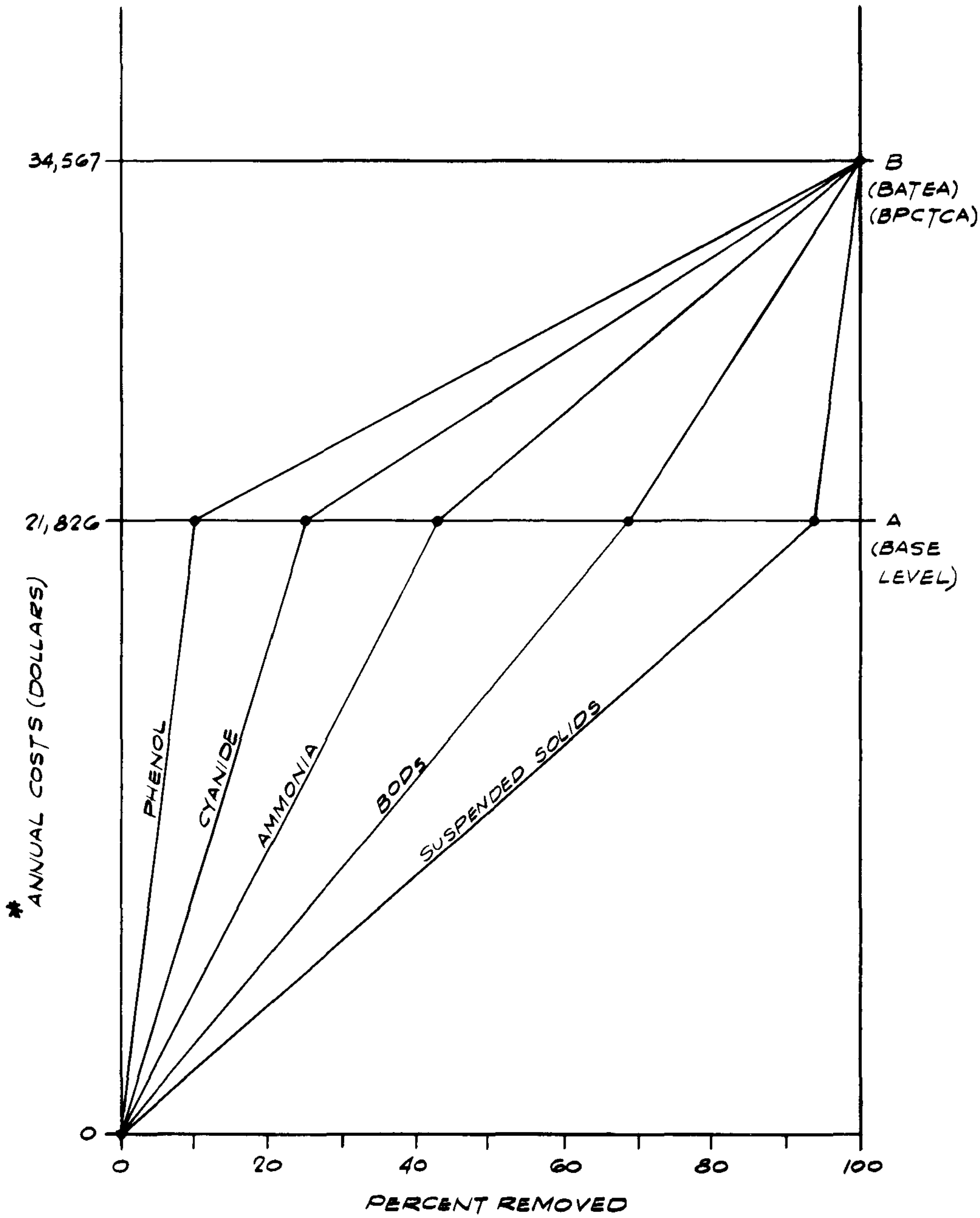


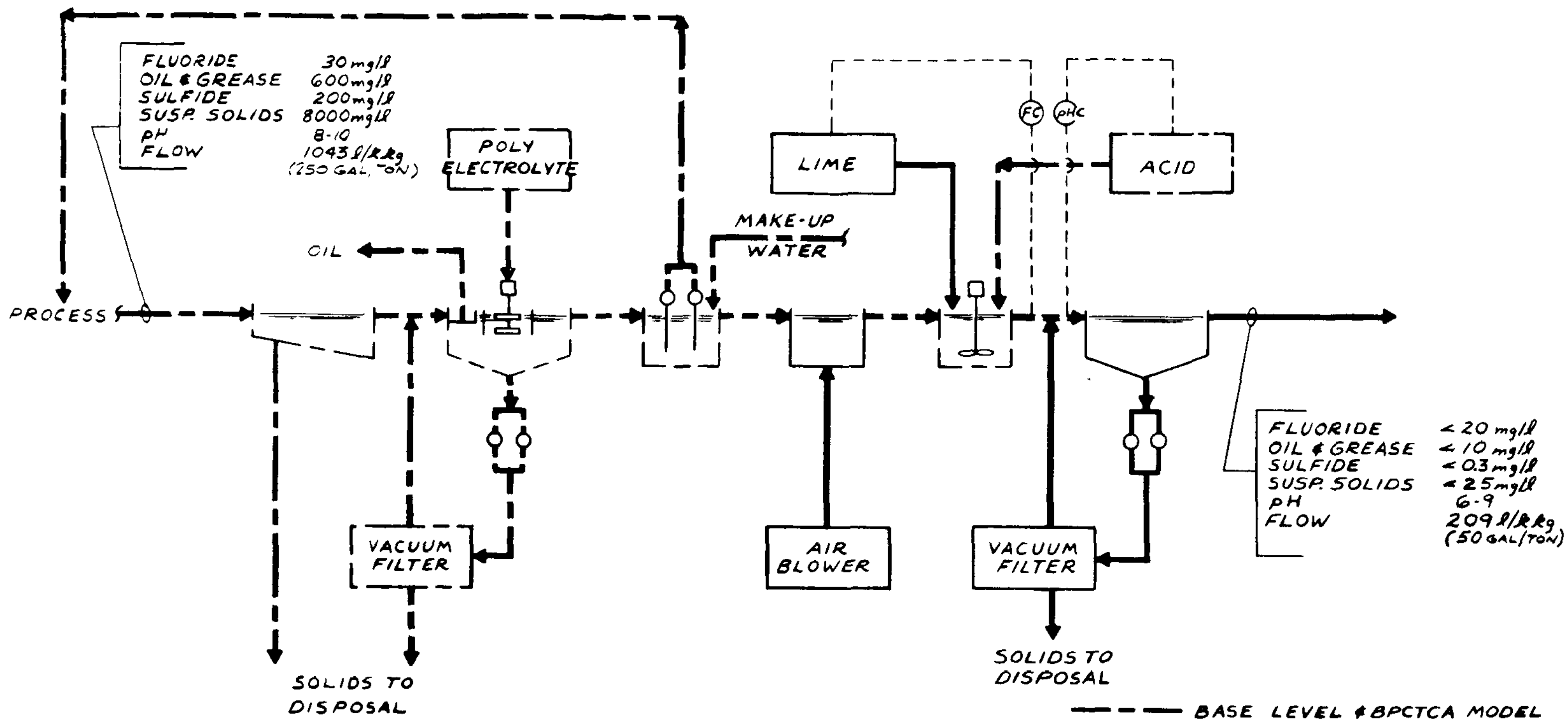
TABLE 79

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Sintering

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0053	25	(Implemented under BPCTCA Standards)	0.0694	0.0630
Oil and Grease	0.0021	10			
Sulfide	0.00006	0.3			
Fluoride	0.0042	20	Blowdown treatment using lime precipitation of fluorides		
pH	6.0-9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of sinter produced (50 gal/ton)(excluding all non contact cooling water)				

(1) Kilograms per metric ton of sinter produced, or pounds per 1000 pounds of sinter produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of sinter produced(50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.



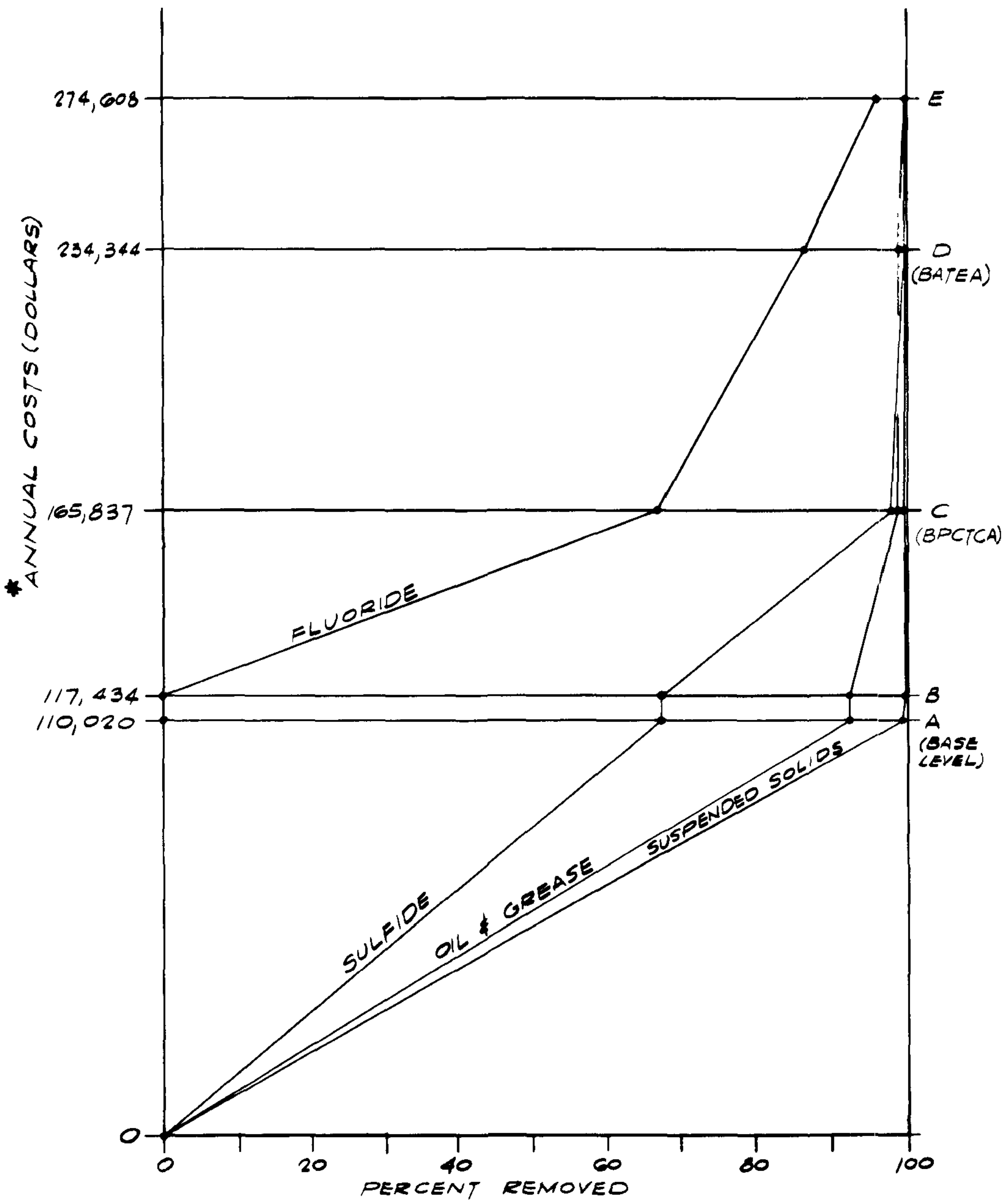
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING SUBCATEGORY
BATEA MODEL

11-14-73	FIGURE 74A

FIGURE 74B

MODEL COST EFFECTIVENESS DIAGRAM
SINTERING SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 2704 KKG/TON (2980 TON/DAY) SINTER PLANT



Three sintering plants were visited, but two of the three systems were deleted from the comparison. These two systems were deleted due to the intricate wastewater treatment system which was utilized not only for the sinter plant but for the blast furnace as well which made separate identification of unit raw waste and unit effluent loads from the sintering operation obscure.

The last sintering plant had wet scrubber systems for both the dedusting and sinter bed exhaust systems. The wastewater treatment system was comprised of a classifier and thickener with recirculation of a portion of the thickener overflow with the difference going to blowdown. Underflow was filtered through vacuum filters.

For the one plant considered under this study, the flow was 475 l/kkg (114 gal/ton) of sinter produced. This value, however, represents a blowdown equivalent to approximately 33% of the process recycle flow of 341 gal/ton. Therefore, the magnitude of the effluent flow was considered uniformly inadequate, since simply tightening up the recycle loop can reduce the effluent discharge by more than 50 percent. In doing this, more attention may have to be paid to control of heat buildup and scaling and/or corrosive conditions in the recycle system. The ELG's were therefore based on 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. This proposed 209 l/kkg (50 gal/ton) is identical to the effluent flow limitations actually found (under this study) for the Open Hearth and BOF gas scrubber recycle systems, thus the technology exchange to a sinter plant should be readily transferable, since the type of recycle system and many of the aqueous contaminants are identical.

After reviewing the laboratory analyses, the critical parameters were established as suspended solids, oils and grease, sulfides, fluoride, pH and the resulting ELG's set as follows:

Suspended Solids

The one plant studied showed 9 mg/l total suspended solids in the final effluent, although this concentration was found in the excessive flow of 475 l/kkg (114 gal/ton) discussed above. This concentration based on 209 l/kkg (50 gal/ton) flows would be equivalent to 21 mg/l. This excellent reduction can apparently be credited to the presence of substantial oil in the raw waste which tends to act as a mucilage on the suspended solids. Similar phenomena have long been known to be responsible for enhancing removal of fine suspended solids in deep bed sand filters. The ELG for total suspended solids was therefore based on 25 mg/l at flows of 209 l/kkg (50 gal/ton) based on measured performance values. The technologies for achieving this are as shown in Table 79.

Oil and Grease

The one plant surveyed was discharging 1.0 mg/l oil and grease at 475 l/kkg (114 gal/ton), which is equivalent to <3 mg/l oil and grease on a 209 l/kkg (50 gal/ton) basis. The ELG for oil and grease for BATEA has been set at 10 mg/l based on a total effluent flow of 209 l/kkg (50 gal/ton) of sintered product. Sampling and analysis techniques currently available mitigate against lowering this standard at this time.

Sulfide

Appreciable sulfide (11 mg/l) was found in the final effluent of the plant surveyed. No reduction was being practiced and therefore this plant was judged to be inadequate with respect to the application of cost effective treatment technology available for sulfide removal. Therefore, the ELG for sulfide was based on 0.3 mg/l at 50 gal/ton based on values achievable by chemical or air oxidation techniques as described in the BATEA limitations discussed above for By Product Coke plants.

Fluoride

For the one plant studied, fluoride was found to be present in the final effluent at 8.5 mg/l. Since substantial At a flow of 475 l/kkg (114 gal/ton), equivalent to 19 mg/l F based on a discharge flow of 209 l/kkg (50 gal/ton). Since substantial fluoride may enter the sintering process from the reuse of steelmaking fines, a standard should be set for the final treated effluent even though in this particular instance the fluoride level was down to values considered to be best available treatment. The BATEA guideline is based on flows of 20 mg/l at 209 l/kkg (50 gal/ton). These values represent the effluent quality attainable through application of treatments including lime precipitation of fluoride, followed by sedimentation for removal of suspended matter. These technologies are currently practiced in a number of raw water treating plants and are readily transferable to wastewater treatment in the steel industry.

pH

For the one plant studied, the pH was found to be 12.7 in the final effluent, apparently due to the use of lime fluxing agents in the sintering process. Although the presence of lime in the process water enhances removal of fluorides, pH levels in this range would definitely have to be classed as detrimental. Appropriate neutralization procedures would have to be applied to attain the pH range required by BPCTCA limitations. No further tightening of the BPCTCA pH range is recommended at this time. The ELG for BATEA remains at pH 6.0 to 9.0.

Blast Furnace (Iron) Subcategory

Waste treatment practices in blast furnace (iron) plants center primarily around removal of suspended solids from the contaminated gas scrubber waters. In past practice, little attention is paid to treatment for other aqueous pollutants in the discharge. Water conservation is practiced in many plants by employing recycle systems.

Three of the four plants surveyed were practicing tight recycle with minimum blowdown. Discharges from these three plants averaged approximately 417 l/kkg (100 gal/ton) of iron produced. The ELG's for BATEA were therefore established conservatively on the basis of 521 l/kkg (125 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. All three blast furnace (iron) plants which practice recycle do achieve this recommended discharge flow. The fourth plant surveyed was running close to a once-through system and was judged inadequate with respect to water conservation, since blast furnace recycle is a well established art.

Cyanide

Only one of the blast furnace (iron) plants surveyed was practicing cyanide removal, via alkaline chlorination of the total discharge flow, yielding a cyanide concentration in the effluent of 0.005 mg/l in a flow of 22,520 l/kkg (5400 gal/ton) of iron produced. This same cyanide load estimated on a 521 l/kkg (125 gal/ton) flow from a recycle system is equivalent to 0.216 mg/l. Therefore, the ELG for cyanide is set at 0.25 mg/l, based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced. Conversion of the once-through system to a recycle system is expected to increase chances for achievement of the BATEA limitation.

Phenol

Two of the three blast furnace (iron) recycle systems were attaining very low phenol concentrations in their discharge flows, equivalent to 0.03 and 0.01 mg/l based on flows of 521 l/kkg (125 gal/ton). The once-through system was attaining an equivalent concentration of 0.6 mg/l at 521 l/kkg (125 gal/ton). Therefore, the ELG for phenol is set at 0.5 mg/l, based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing technology currently practiced in the blast furnace (iron) subcategory.

Ammonia

None of the three blast furnace (iron) recycle systems surveyed were attaining less than 75 mg/l of ammonia in the effluent. Only the once-through system, utilizing alkaline chlorination, attained low ammonia levels of 0.84 mg/l in 22,520 l/kkg (5400 gal/ton), equivalent to 36 mg/l based on a flow of 521 l/kkg (125 gal/ton). This system can be upgraded by providing a recycle loop, improved alkaline chlorination treatment of the blowdown, filtration and carbon adsorption to provide a

TABLE 80

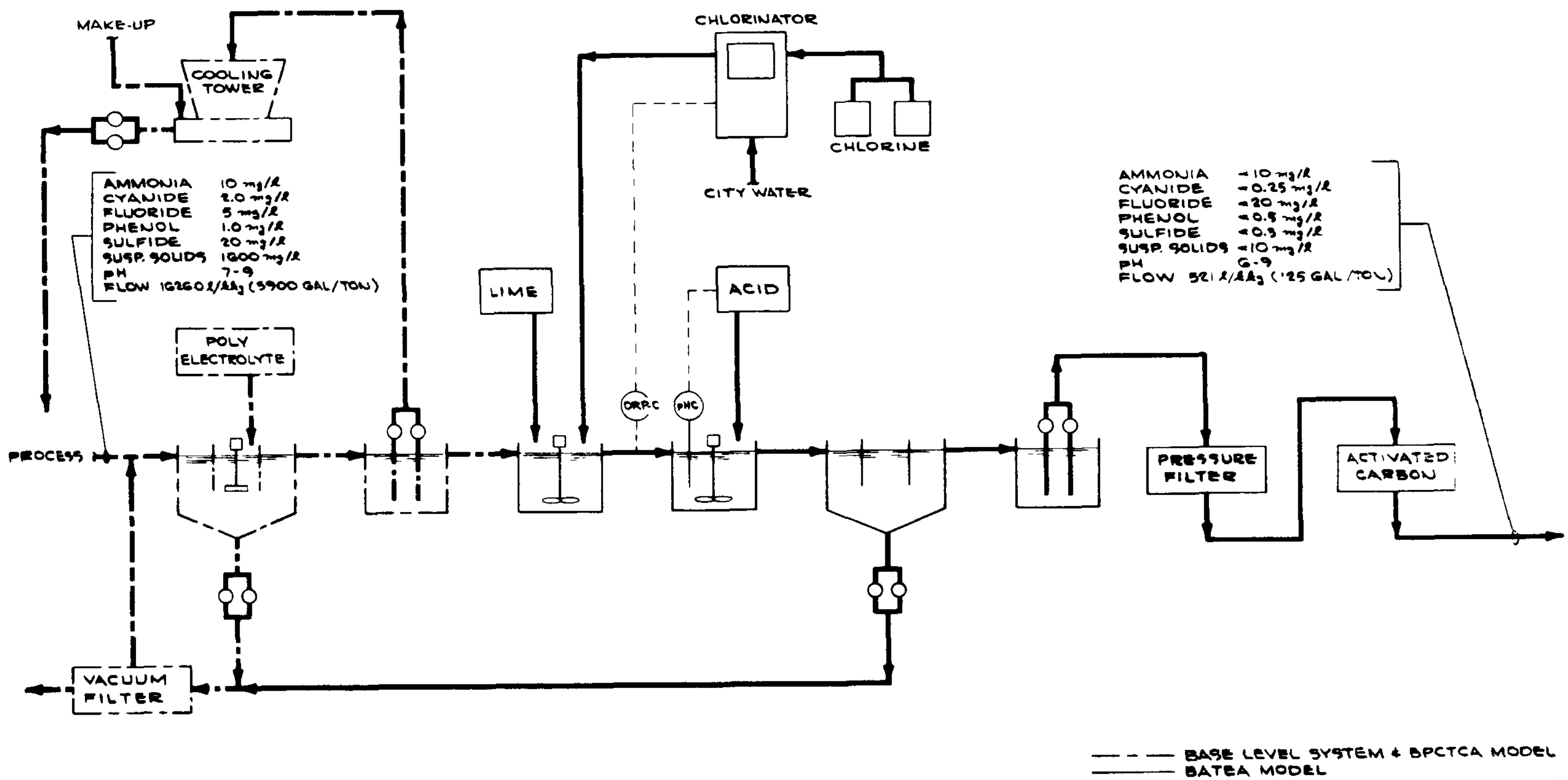
BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Blast Furnace (Iron)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB)	mg/l[2]	CONTROL & TREATMENT TECHNOLOGY[3]	ESTIMATED[4] TOTAL COST $/KKg	$/TON
Suspended Solids	0.0052	10	BPCTCA plus:		
*Cyanide A	0.00013	0.25	Treatment of cooling		
Phenol	0.00026	0.5	Tower blowdown via:		
Ammonia	0.0052	10	Alkaline chlorination	0.267	0.242
Sulfide	0.00016	0.3	Pressure Filtration		
Fluoride	0.0104	20	Carbon adsorption.		
pH	6.0 - 9.0		pH neutralization		
Flow	Most probable value for tight system is 522 liters effluent per kkg of coke produced (125 gal/ton) (excluding all non-contact cooling water.)				

(1) Kilograms per metric ton of iron produced, or pounds per 1000 pounds of iron produced.
(2) Milligrams per liter based on 522 liters effluent per kkg of iron produced (125 gal/ton).
(3) Available technology listed in not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination. Reference ASTM D 2036-72 Method B.



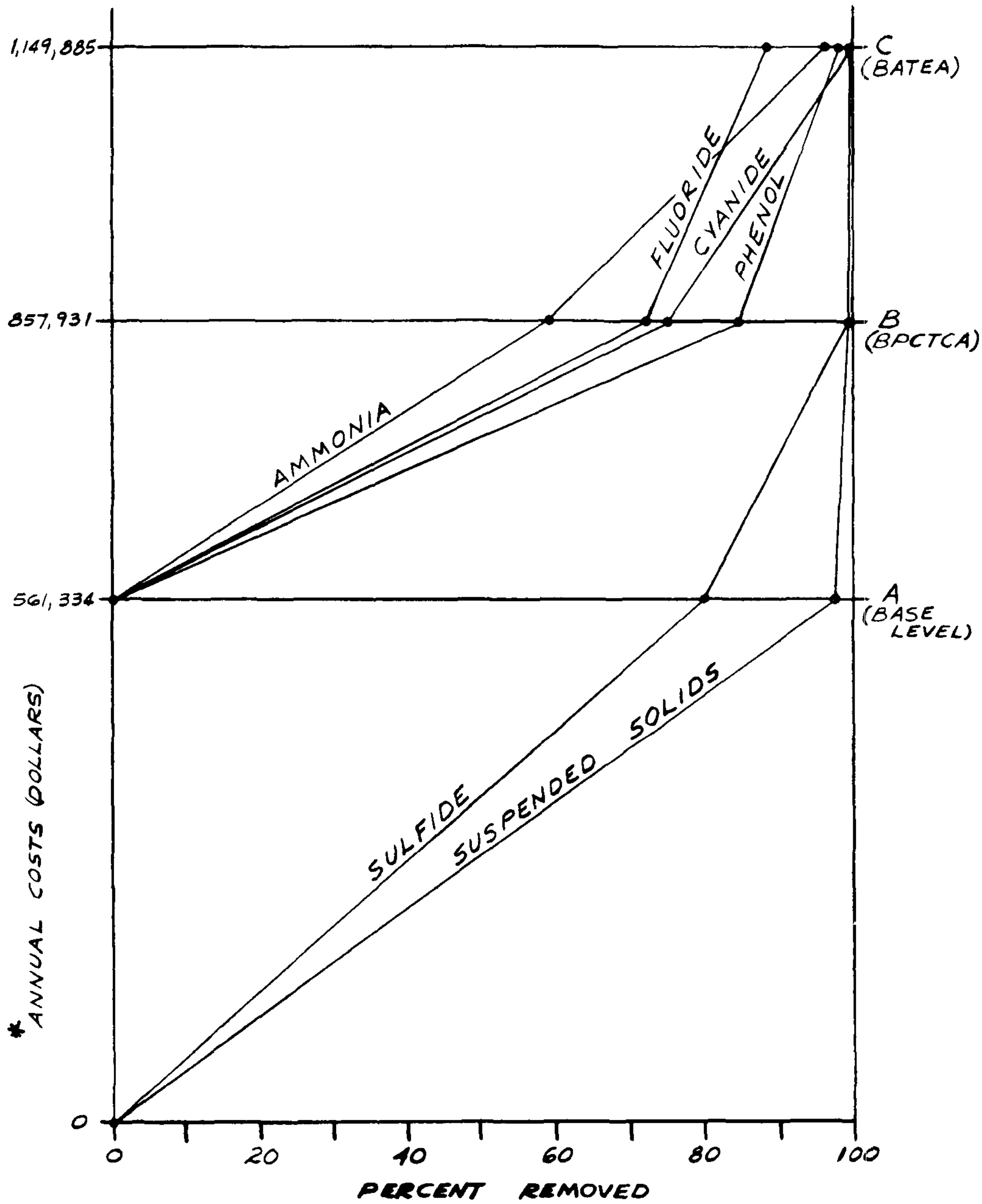
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE (IRON) SUBCATEGORY
BATEA MODEL

11-10-75	FIGURE 75A

FIGURE 75B

MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (IRON) SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 2995 KKG/DAY (3300 TON/DAY) IRON PRODUCTION



lower final ammonia concentration. Therefore, the ELG for ammonia is set at 10 mg/l, based on a discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing technology currently practiced in the blast furnace (iron) subcategory modified by additional technology transferred from the petrochemical industry.

Sulfur

None of the four plants surveyed was attaining adequate sulfide levels, although the plant utilizing alkaline chlorination was discharging a concentration of 0.043 mg/l in the once-through system, equivalent to 1.86 mg/l in 521 l/kkg (125 gal/ton). The improvements to this system described previously under Ammonia can serve to drive sulfide removals significantly further. Therefore, the ELG for sulfide is set at 0.3 mg/l based on a discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing the technology described above.

Suspended Solids

Only the once-through system was achieving acceptable suspended solids concentrations in the effluent, although in terms of load, this system was discharging excessive solids. An abundance of technology exists for reducing suspended solids in a cost effective manner. For this reason, and for insuring the efficient operation of the carbon adsorption equipment referred to above, an ELG for suspended solids of 10 mg/l based on a discharge flow of 521 l/kkg (125 gal/ton) of iron is proposed, utilizing existing technology for solids removal.

Fluoride

Since substantial quantities of fluoride may occur in certain raw materials used in blast furnace (iron) operations, a limitation on this parameter is desirable. All four operating plants surveyed showed equivalent concentrations of fluoride ranging between 8.4 and 22.6 mg/l based on discharge flows of 521 l/kkg (125 gal/ton). Even though these plants show fluoride levels approaching BATEA, an ELG is set at 20 mg/l based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced to provide control over plants which may show higher raw waste fluoride concentrations. The lime precipitation and sedimentation treatment referred to above in discussing sintering plants is the treatment technology of choice.

pH

All four plants surveyed discharge effluents well within the BATEA pH range recommended elsewhere. In the event that lime precipitation of fluorides is required, the effluent pH may have to be adjusted with acid addition to remain within the desired 6.0 to 9.0 pH range.

Blast Furnace (Ferromanganese) Subcategory

Only one operating ferro-manganese furnace was found for the survey. The one plant surveyed was operating on a close to once-through basis of 23,770 l/kkg (5700 gal/ton) of ferro-manganese produced. This flow would have to be considered uniformly inadequate since there is no reason precluding running a recycle system identical to that of the iron producing blast furnaces, except that a blowdown rate of 1043 l/kkg (250 gal/ton) is recommended for the reasons discussed in section IX.

BATEA limitations proposed for the blast furnace (iron) subcategory are applicable to blast furnace (ferromanganese) plants, except that the higher flow rates do provide for discharge of twice the load from the latter. All of the treatment and control technologies described above for achieving blast furnace (iron) BATEA limitations are applicable to blast furnace (ferromanganese) plants, with one exception. Raw waste loads for ferromanganese operations indicate that fluoride loads are relatively minor, and therefore do not require control. However, a high load of manganese results from this process, and must be controlled by the treatment technology. Since most of the manganese is in the suspended solid form, it is effectively removed with the suspended solids, as described above.

The ELG for all parameters to be controlled by application of BATEA for blast furnace (ferromanganese) plants is summarized as follows: cyanide 0.25 mg/l; phenol 0.5 mg/l; ammonia 10 mg/l; sulfide 0.3 mg/l; suspended solids 10 mg/l; and manganese 5 mg/l. All concentrations are based on a total effluent flow of 1,043 l/kkg (250 gal/ton).

Basic Oxygen Furnace Operation

The only direct contact process water used in the BOF plant is the water used for cooling and scrubbing the off gases from the furnaces. Two methods which are employed and can result in an aqueous discharge are the semi-wet gas cleaning and wet gas cleaning systems as defined in Types II, III, IV and V on Figures 17 through 20, inclusive.

Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory

The two semi-wet systems surveyed had different types of wastewater treatment systems. The first system was comprised of a drag link conveyor, settling tank, chemical flocculation and complete recycle pump system to return the clarified treated effluent to the gas cleaning system. Make-up water was added to compensate for the evaporative water loss and the system had zero (0) aqueous discharge of blowdown. The second semi-wet system was comprised of a thickener with polyelectrolyte addition followed by direct discharge to the plant sewers on a "once-through" basis.

Because of the nature of these semi-wet systems, direct blowdown is not required when recycle is employed. The systems are kept in equilibrium

TABLE 81

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Blast Furnace (Ferromanganese)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0104	10	BPCTCA plus:		
*Cyanide A	0.00026	0.25	Treatment of system		
Phenol	0.00052	0.5	blowdown via:		
Ammonia (as NH_3)	0.0104	10	Alkaline chlorination.	1.927	1.749
Sulfide	0.00031	0.3	Pressure filtration.		
Manganese	0.0052	5	Carbon adsorption.		
pH	6.0 - 9.0		pH neutralization		
Flow:	Most probable value for tight system is 1043 liters per kkg of ferromanganese produced (250 gal/ton) (excluding all non-contact cooling water).				

(1) Kilograms per metric ton of ferromanganese produced or pounds per 1000 pounds of ferromanganese produced.
(2) Milligrams per liter based on 1043 liters per kkg of ferromanganese produced (250 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination. Reference ASTM D 2036-72 Method B.

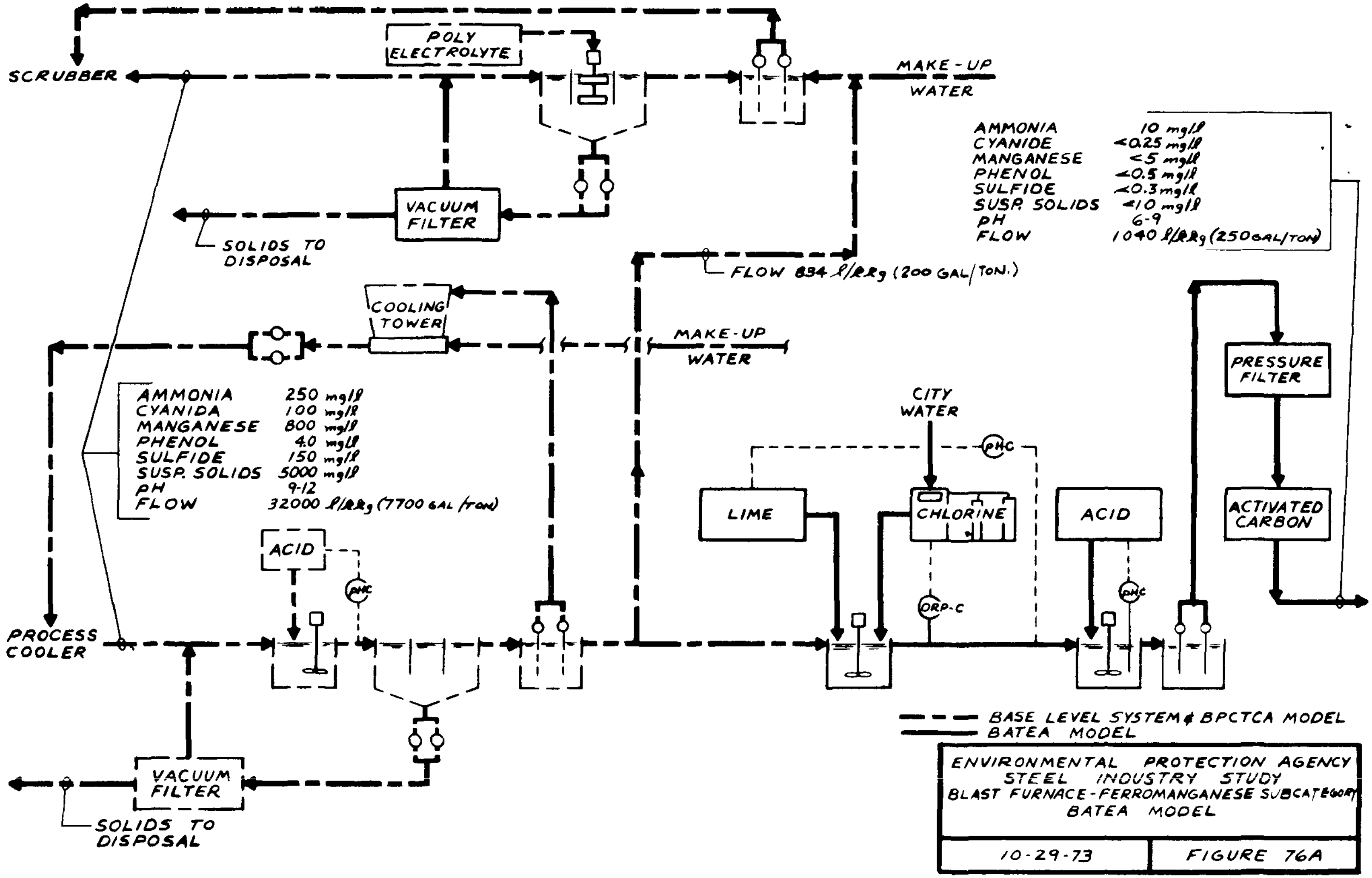

SCRUBBER
POLY ELECTROLYTE
MAKE-UP WATER
VACUUM FILTER
SOLIDS TO DISPOSAL
AMMONIA 10 mg/l
CYANIDE <0.25 mg/l
MANGANESE <5 mg/l
PHENOL <0.5 mg/l
SULFIDE <0.3 mg/l
SUSP. SOLIDS <10 mg/l
pH 6-9
FLOW 1040 l/kkg (250 GAL/TON)
FLOW 834 l/kkg (200 GAL/TON)
COOLING TOWER
MAKE-UP WATER
AMMONIA 250 mg/l
CYANIDA 100 mg/l
MANGANESE 800 mg/l
PHENOL 40 mg/l
SULFIDE 150 mg/l
SUSP. SOLIDS 5000 mg/l
pH 9-12
FLOW 32000 l/kkg (7700 GAL/TON)
CITY WATER
PHC
LIME
CHLORINE
ACID
ORP-C
PRESSURE FILTER
ACTIVATED CARBON
ACID
PHC
PROCESS COOLER
VACUUM FILTER
SOLIDS TO DISPOSAL
BASE LEVEL SYSTEM & BPCTCA MODEL
BATEA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE-FERROMANGANESE SUBCATEGORY
BATEA MODEL
10-29-73
FIGURE 76A

FIGURE 76B

MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (FERROMANGANESE) SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDING LABOR, CHEMICALS, & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5 % OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 744 KKG/DAY (820 TON/DAY) FeMn PRODUCTION

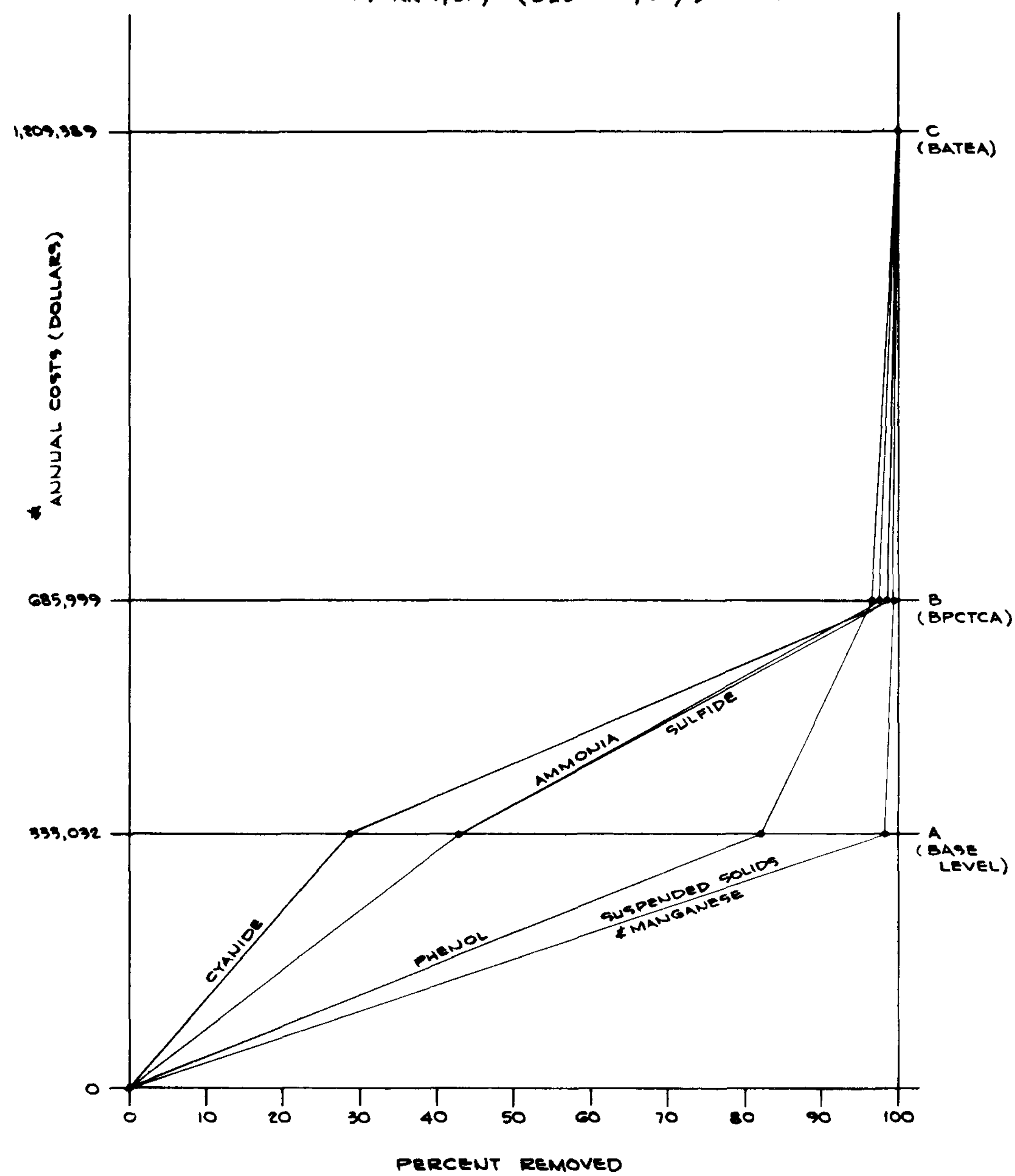


TABLE 82

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Basic Oxygen Furnace (Semi-wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	BATEA LIMITATIONS mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	ESTIMATED (4) TOTAL COST $/TON
Suspended Solids Fluoride pH Flow	No discharge of process wastewater pollutants to navigable waters (excluding non-contact cooling water)		Same as BPCTCA	Zero (0)	

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

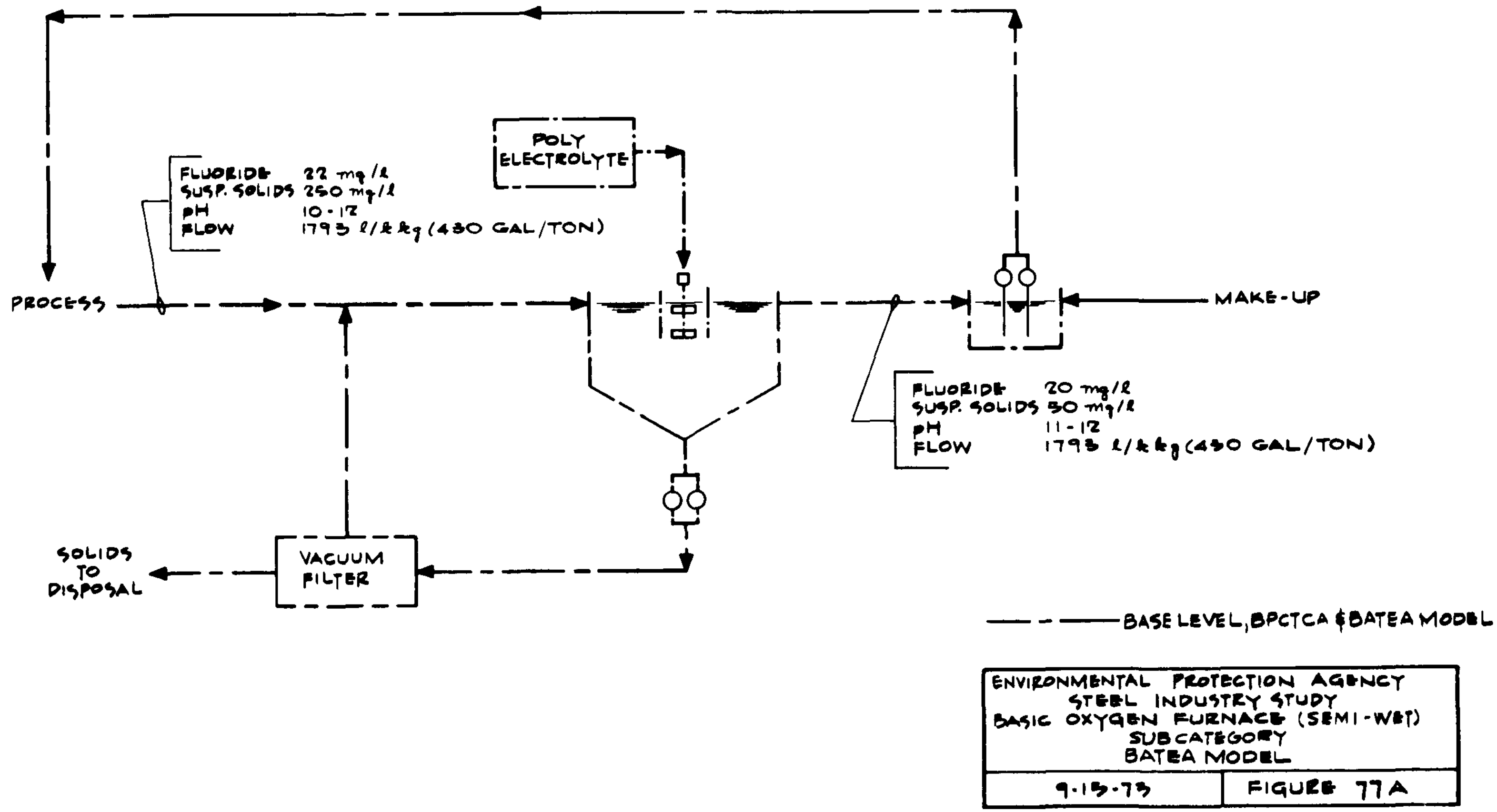

PROCESS
FLUORIDE 22 mg/l
SUSP. SOLIDS 250 mg/l
pH 10-12
FLOW 1793 l/kkg (430 GAL/TON)
POLY ELECTROLYTE
MAKE-UP
FLUORIDE 20 mg/l
SUSP. SOLIDS 50 mg/l
pH 11-12
FLOW 1793 l/kkg (430 GAL/TON)
VACUUM FILTER
SOLIDS TO DISPOSAL
BASE LEVEL, BPCTCA & BATEA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE (SEMI-WET)
SUBCATEGORY
BATEA MODEL
9-15-73
FIGURE 77A

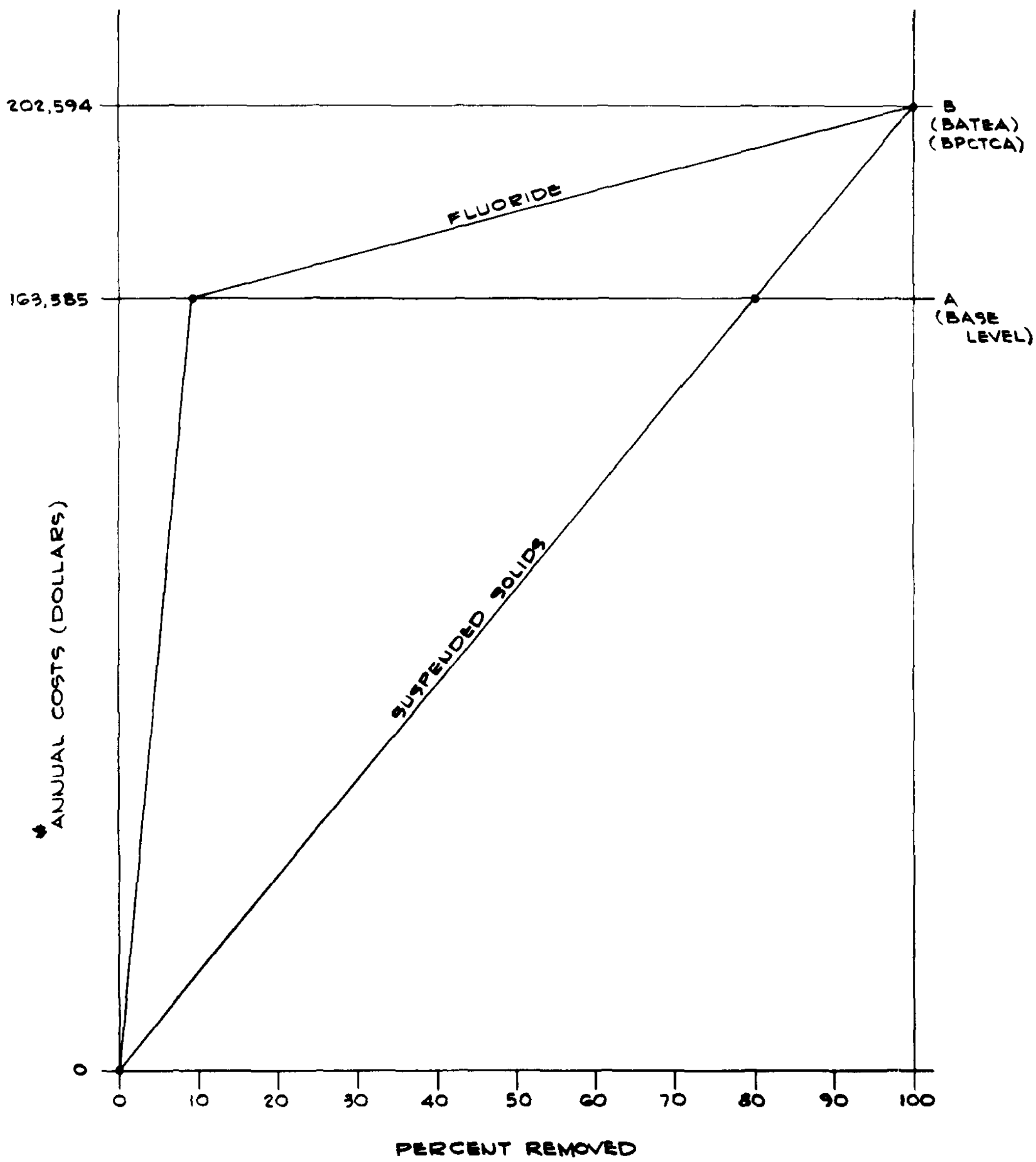
FIGURE 77B

MODEL COST EFFECTIVENESS DIAGRAM
BASIC OXYGEN FURNACE
(SEMI-WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY

*ANNUAL COSTS - BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDING LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5 % OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 4429 KKG/DAY (4880 TON/DAY) BOF SHOP



by water losses to the sludge and to entrainment carry-over into the hot gas stream. Most new wet BOF systems are designed in this manner. Therefore, the BATEA for this operation has been established as no discharge of process wastewater pollutants to navigable waters. This requirement had previously been set as BPCTCA limitations for this subcategory.

Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

The three BOF wet systems surveyed were generally of the same type and included classifiers and thickeners with recirculation of a portion of the clarifier effluent. The blowdown rates were 33, 52, and 217 gallons per ton of steel produced, respectively, with the latter system discharging in excess of the blowdown normally required for recycle systems of this type. The ELG's were therefore established on the basis of discharge flows of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The effluent suspended solids were 22, 40, and 71 mg/l, respectively, for the three plants surveyed. The first two of these concentrations are equivalent to 23 and 26 mg/l at the recommended flow of 209 l/kkg (50 gal/ton), so the ELG for suspended solids is set at 25 mg/l based on a total discharge flow of 209 l/kkg (50 gal/ton). As indicated under discussion of blast furnaces, the technology is well established for reducing iron-laden suspended solids to less than 25 mg/l with the use of chemical and/ or magnetic flocculation. This technology is currently utilized within this subcategory.

Fluoride

Fluoride was only measured at one of the three BOF wet systems surveyed and was found to be 14 mg/l, equivalent to 63 mg/l based on a total discharge flow of 209 l/kkg (50 gal/ton). As discussed under sinter plants, fluoride is a normal by-product of steelmaking where fluoride-containing fluxes are employed and as a result shows up in the sinter plant effluent and blast furnace effluent due to the recycle and reuse of steelmaking fines. The BATEA guideline for fluoride has been based on 20 mg/l at 209 l/kkg (50 gal/ton) for the reasons discussed above in the sintering subcategory. This value represents the effluent quality attainable by the application of the best available method of treatment for removal of fluorides, i.e. lime precipitation followed by sedimentation for particulate removal. This technology is currently practiced in a number of raw water treating plants and is readily transferable to wastewater treatment in the steel industry.

pH

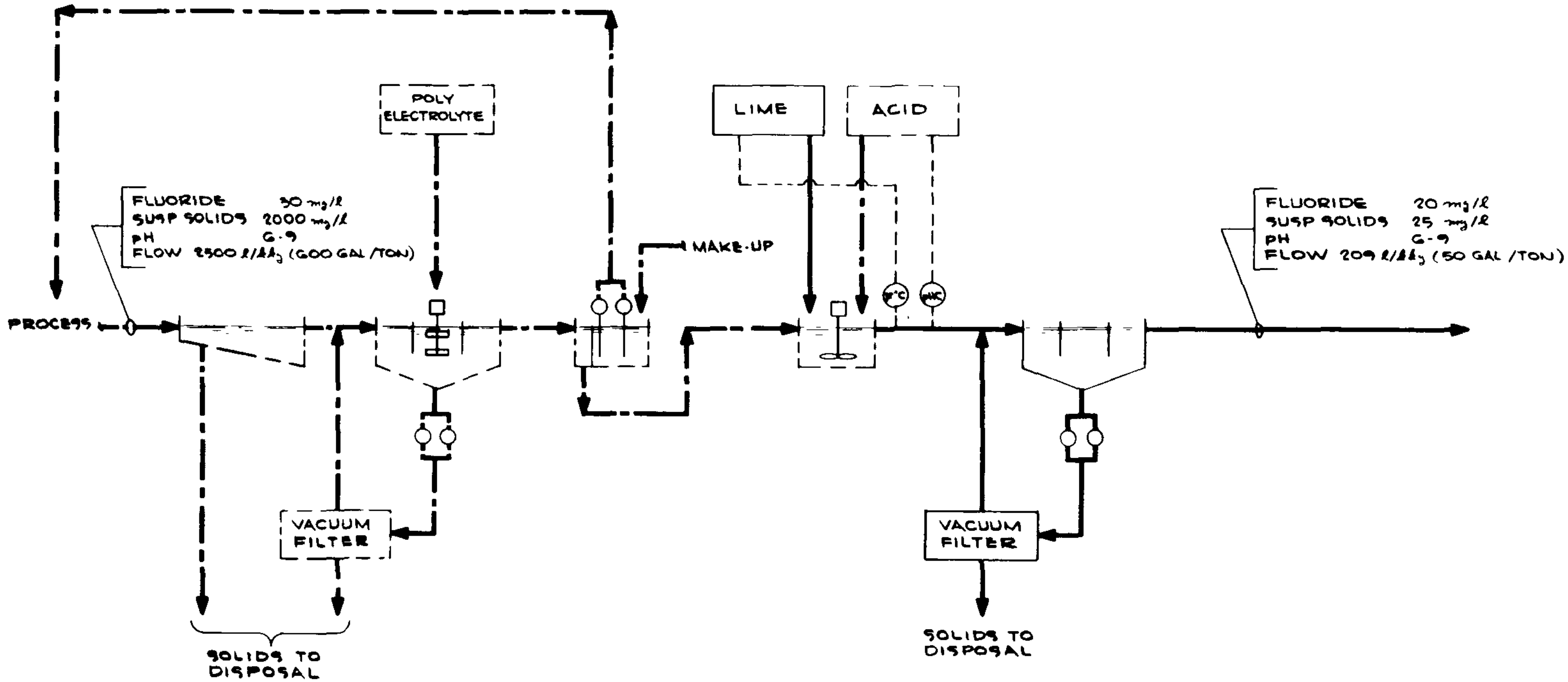
TABLE 83

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Basic Oxygen Furnace (Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg(1) (LB/1000 LB)	mg/l(2)	CONTROL & TREATMENT TECHNOLOGY(3)	ESTIMATED(4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0052	25	Blowdown treatment with sand filtration or improved settling with coagulation	0.0328	0.0298
Fluoride	0.0042	20	Blowdown treatment using lime precipitation of fluorides.		
pH	6.0 - 9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton) (excluding all non-contact cooling water).				

(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.



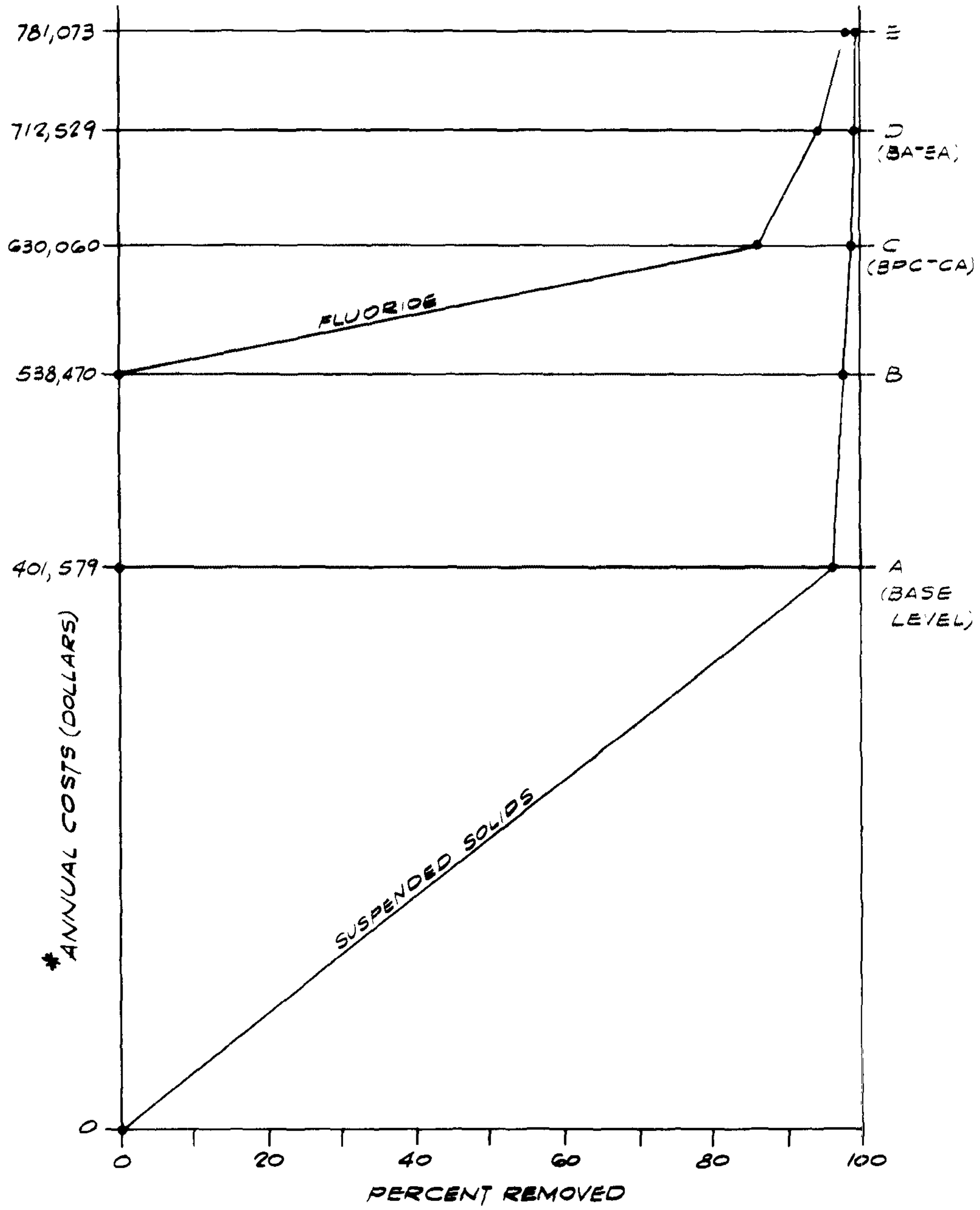
BASE LEVEL & BPCTCA MODEL
BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY STEEL INDUSTRY STUDY BASIC OXYGEN FURNACE (WET) SUBCATEGORY BATEA MODEL

11-15-73	FIGURE 78A

FIGURE 78B

MODEL COST EFFECTIVENESS DIAGRAM
BASIC OXYGEN FURNACE
(WET AIR POLLUTION CONTROL METHODS) SUBCATEGORY
*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 6888 KKG/DAY (7590 TON/DAY) BOF SHOP



The pH of the three plants surveyed varied from 6.4 to 9.4. As with previous subcategories, the BATEA standards for pH are the same as BPCTCA limits for this parameter. If excess lime is used in the fluoride precipitation step, the effluent pH may have to be adjusted with acid to remain in the desired 6.0 to 9.0 pH range.

Open Hearth Furnace Subcategory

As with the BOF furnaces, only contact process waters were surveyed, sampled and analyzed. Again the only contact process water in the open hearth is the water used for cooling and scrubbing the waste gases from the furnaces. As a general rule, open hearths have dry precipitator systems rather than scrubbers. Therefore, only two open hearth shops were surveyed and each had a wet high energy venturi scrubber system as defined in Types I, II, III shown on Figures 21, 22, and 23, respectively. There are no semi-wet systems for open hearths.

Each plant had a similar wastewater treatment system comprised of classifiers, with thickeners with recirculation of a portion of the thickener overflow. One system utilized vacuum filters for thickener underflow while the other system used slurry pumps and pumped the thickener wastes to tank trucks for disposal. The blowdown rates varied between 213 l/kkg (51 gal/ton) and 492 l/kkg (118 gal/ton) but the latter represented a 22% blowdown and the former about 9%.

These systems can be tightened as was indicated for the BOF and therefore the ELG's were established on the basis of 209 l/kkg (50 gal/ton) of product and concentrations of the process pollutant parameters achievable by the indicated treatment technologies.

A review of the data collected resulted in the following effluent guidelines:

Suspended Solids

For the two plants surveyed, the effluent suspended solids were 80 and 52 mg/l. As with the similarly operated BOF wet recycle systems, less than 25 mg/l suspended solids can readily be achieved and therefore the two open hearth plants surveyed were judged uniformly inadequate respect to achieving this level.

Similar to the BOF wet system, the BATEA ELG for suspended solids has been based on 25 mg/l at 209 l/kkg (50 gal/ton) based on the use of conventionally available coagulation and/or filtration techniques as indicated in Table 84. This technology is currently utilized in other iron and steel industry subcategories for attaining the proposed BATEA limitations, and should achieve similar results in the open hearth subcategory.

Fluoride

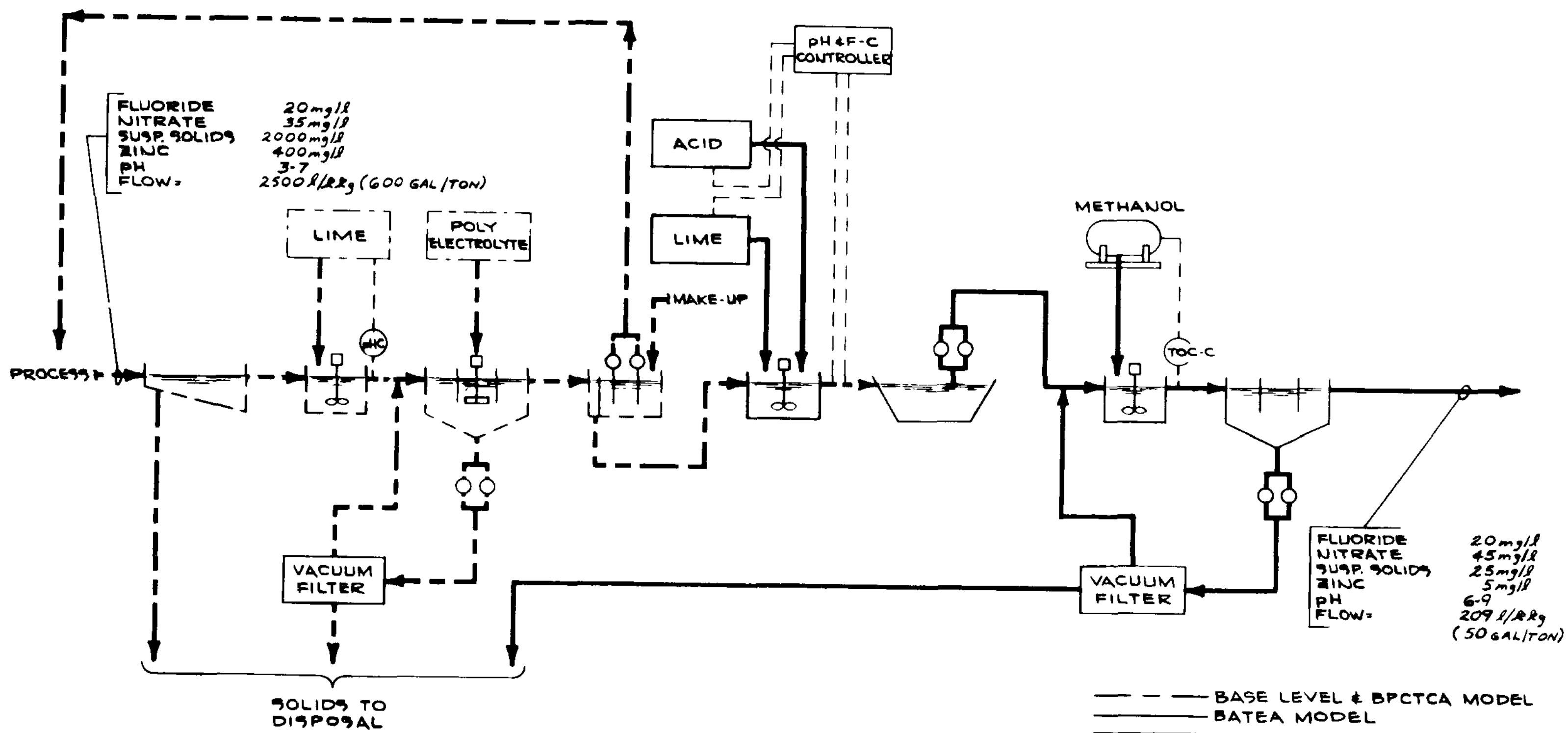
TABLE 84

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Open Hearth Furnace

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL CCST $/KKg	$/TON
Suspended Solids	0.0052	25	Blowdown treatment with sand filtration or improved settling with coagulation		
Fluoride	0.0042	20	Blowdown treatment using lime precipitation of fluorides	0.126	0.114
Nitrate (as NO_3)	0.0094	45	Anaerobic denitrification		
Zinc	0.0010	5	Reduction occurs as a result of improved suspended solids removal		
pH	6.0 - 9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non-contact cooling water).				

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.



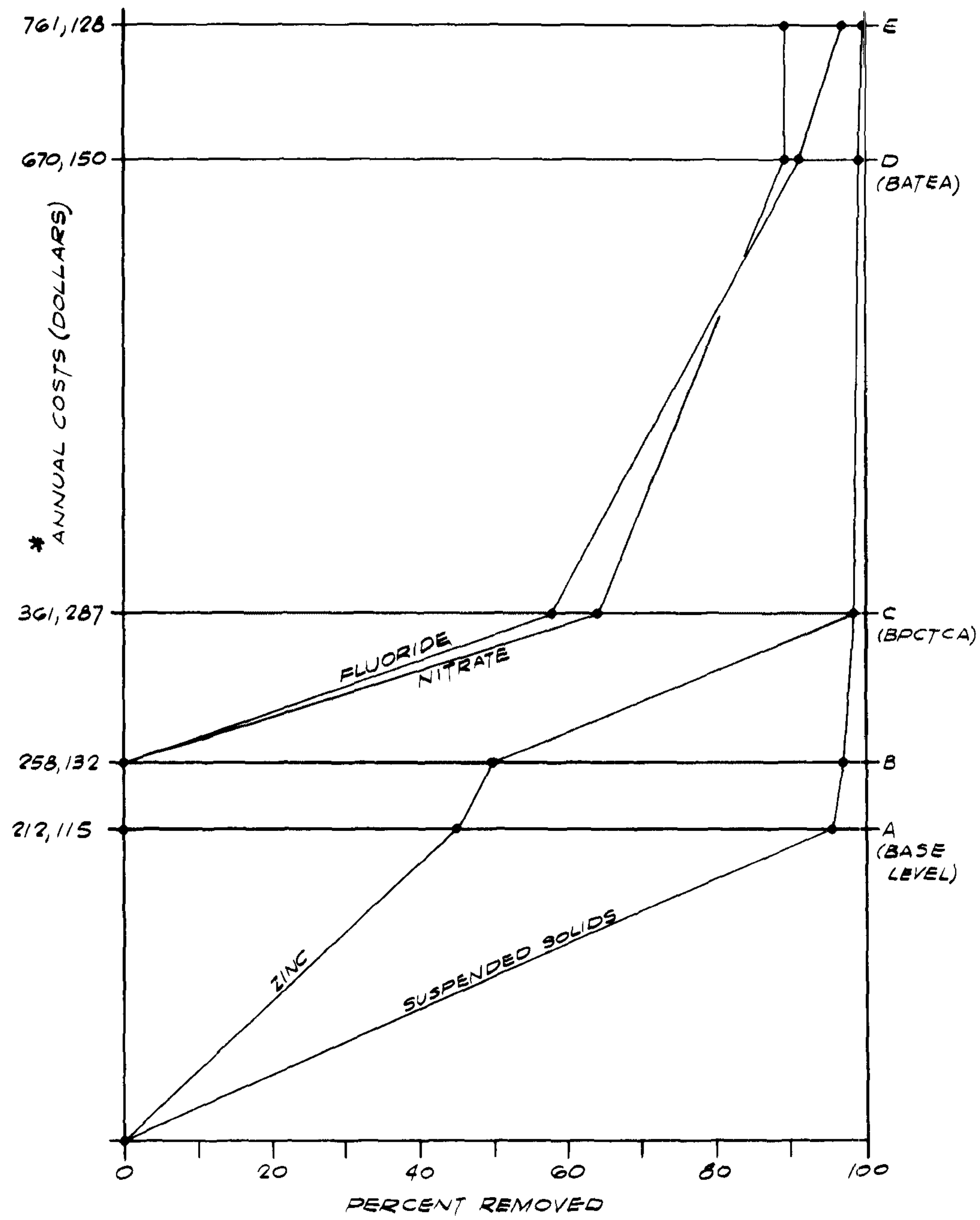
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE SUBCATEGORY
BATEA MODEL

11-14-73	FIGURE 79A

FIGURE 79B

MODEL COST EFFECTIVENESS DIAGRAM
OPEN HEARTH FURNACE SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 6716 KKG/DAY (7400 TON/DAY) OH SHOP



The two plants surveyed showed fluoride levels in their final effluents of 65 and 148 mg/l. No reduction was being practiced and the plants were judged uniformly inadequate with respect to the application of cost effective treatment technology available for fluoride removal. The ELG for fluoride is based on 20 mg/l at 209 l/kkg (50 gal/ton) for the reasons discussed above in the sintering subcategory. This value represents the best available method of treatment for removal of fluorides. The technology for achieving this is shown in Table 84.

Nitrate

For the two plants surveyed, nitrate was found to be 22 and 303 mg/l in the respective final effluents. The latter plant was judged to be inadequate with respect to employing treatment techniques for removal of the gross level of nitrate measured. This high level can probably be attributed to the type and quantity of combustion fuel used in the burners. The BATEA guideline for nitrate has been based on 45 mg/l at 209 l/kkg (50 gal/ton). The technology employed for nitrate removal usually encompasses anaerobic denitrification and since the removal efficiency of this technique is highly temperature-dependent, the rather liberal ELG of 45 mg/l was selected to provide sufficient flexibility for seasonal temperature changes. Anerobic denitrification to less than this level has been recently practiced in treatment of domestic sewage where regulatory agencies have required it. Lower nitrate values could be achieved for these BATEA guidelines, however, the costs for obtaining same would not be cost effective in relation to the minor improvements gained.

Zinc

For the two plants surveyed, the effluent zinc concentrations were measured at 26 and 1210 mg/l. No reduction was being practiced and the plants were judged uniformly inadequate with respect to the application of cost effective treatment technology available for zinc removal. These high levels can probably be attributed to the type and amount of scrap charged to the furnaces. The BATEA guideline for zinc is based on 5 mg/l at 209 l/kkg (50 gal/ton). This limit is based upon best available technology, as extensively practiced by the metal finishing industry for zinc removal. More effective removal of particulate matter consistent with the required reduction in suspended solids should effect the further reduction in this parameter to the 5 mg/l concentration on which the BATEA ELG is based.

pH

The pH was found to be 6.1 and 1.8-3.4, respectively, for the two plants surveyed, with the latter plant being judged inadequate with respect to proper control of pH. The pH range for BATEA has been set at 6.0 to 9.0. The ranges are readily attainable through the use of suitable chemicals and closer control of neutralization techniques as previously discussed.

Other

Although significant levels of sulfides did not appear in the effluent analyses, these effluents should be monitored to determine if a sulfide limitation should be applied, i.e. 0.3 mg/l in 209 l/kkg (50 gal/ton) due to the many high sulfur fuels such as No. 6 fuel oil that may be used for firing open hearth furnaces.

Electric Arc Furnace Operation

The electric arc furnace waste gas cleaning systems are similar in nature to the BOF, i.e. they may be dry, semi-wet or wet systems as defined in Types I, II, III, and IV shown on Figures 24 through 27. Four plants were surveyed, two semi-wet and two wet systems.

Electric Arc Furnace (Semi Wet Air Pollution Control Methods Subcategory

The two semi-wet systems had similar wastewater treatment systems comprised of a settling tank with drag link conveyor; one system was recycled with no aqueous blowdown while the other system had closely regulated the furnace gas cooling water spray system so that only a wetted sludge was discharged to the drag tank for subsequent disposal. Therefore, the BATEA for semi-wet systems has been establised as "no discharge of process wastewater pollutants to navigable waters", as previously set for BOCTCA limitations in this subcategory.

Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

The two wet systems surveyed had similar wastewater treatment systems. Both plants were recirculating waste waters without treatment at the rate of 12,500 l/kkg (3000 gal/ton) and treating blowdowns of 6 and 10%, respectively. Since these systems can be made essentially identical to the BOF and open hearth recycle systems for gas scrubbing, the ELG's were established on the basis of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutants parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids, Fluoride, Zinc, and pH

All of the above indicated critical parameters are likewise found in the open hearth subcategory. Since the treatment technology for their reduction is the same, the ELG's for these parameters have been based on the same values established for the open hearth. These limitations and the corresponding technologies for achieving same are given in Table 86.

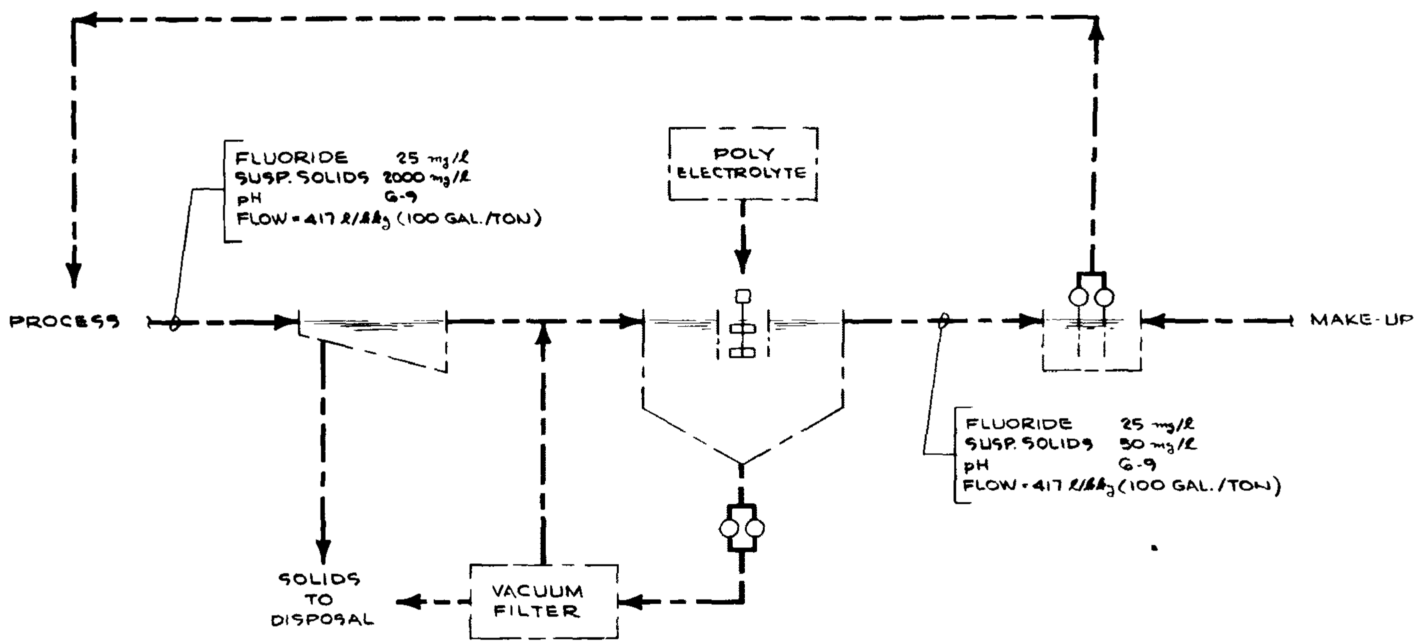
TABLE 85

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Semi-wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids Fluoride Zinc pH Flow	No discharge of process wastewater pollutants to navigable waters (excluding all non-contact cooling water)		Same as BPCTCA	Zero (0)	

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have installed as a result of complying with BPCTCA standards.



— — — BASE LEVEL, BPCTCA & BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY STEEL INDUSTRY STUDY ELECTRIC ARC FURNACE (SEMI-WET) SUBCATEGORY BATEA MODEL	
11-15-79	FIGURE 80A

FIGURE 80B

MODEL COST EFFECTIVENESS DIAGRAM
ELECTRIC ARC FURNACE
(SEMI-WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 1488 KKG/DAY (1640 TON/DAY) EAF SHOP

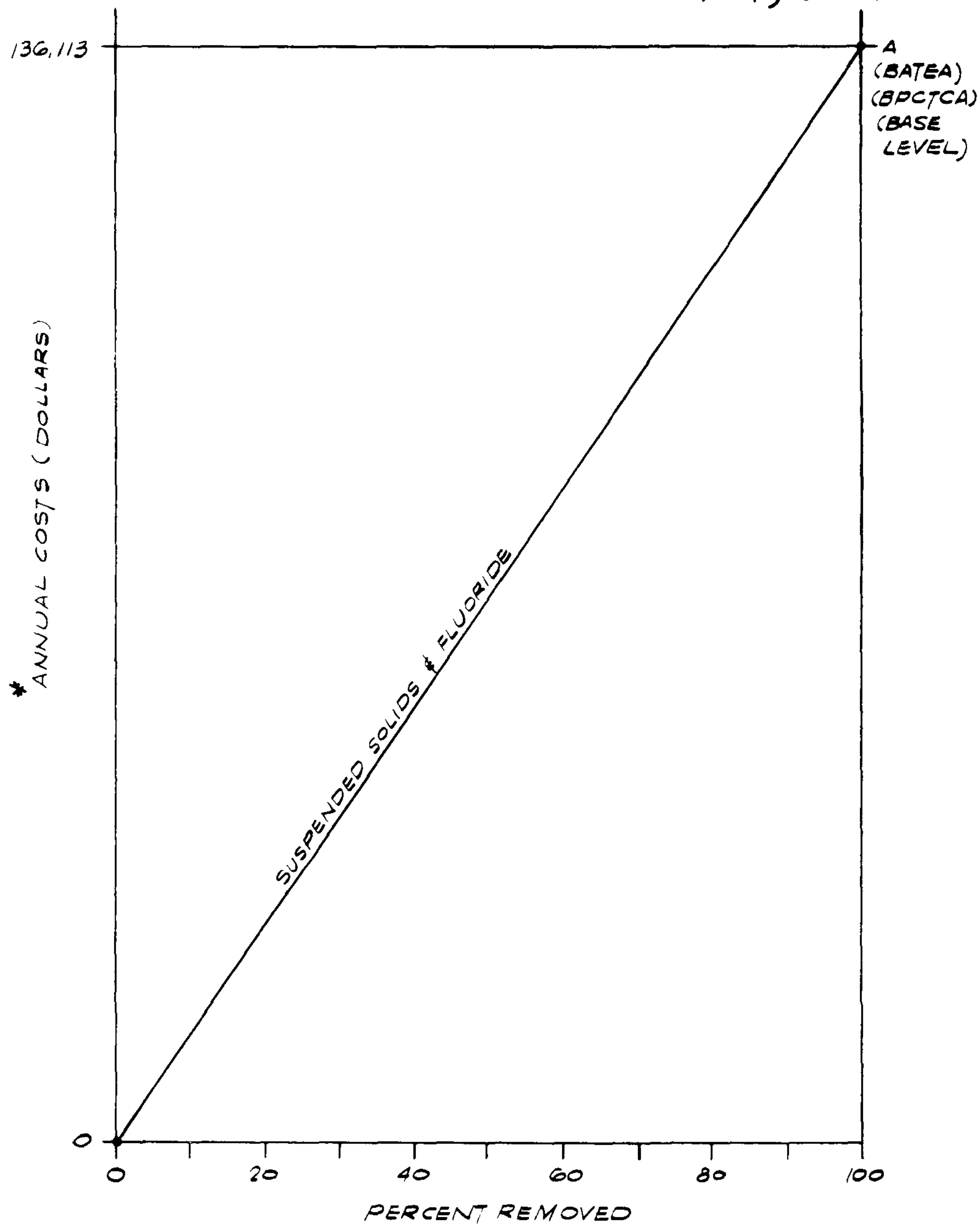


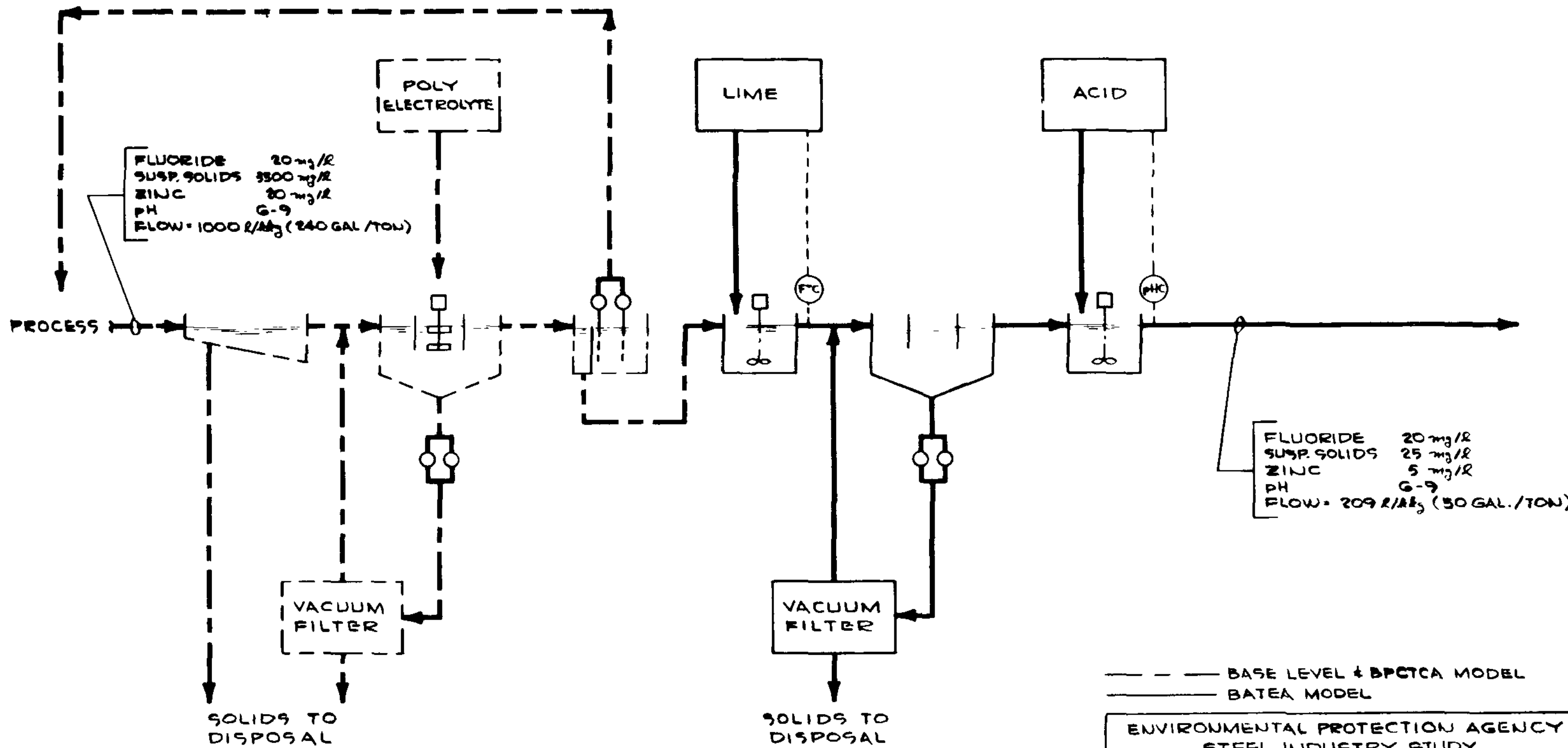
TABLE 86

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Wet Air Pollution Control Methods)

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (LB/1000 LB) (1)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0052	25	Blowdown treatment with sand filtration or improved settling with coagulation	0.0988	.0897
Fluoride	0.0042	20	Blowdown treatment using lime precipitation of fluorides		
Zinc	0.0010	5	Reduction occurs as a result of improved suspended solids removal		
pH	6.0 - 9.0		Neutralization		
Flow	Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton) (excluding all non-contact cooling water)				

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 leters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does is reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability or land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extend of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.



ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC ARC FURNACE (WET)
SUBCATEGORY
BATEA MODEL

11-15-73	FIGURE 81A

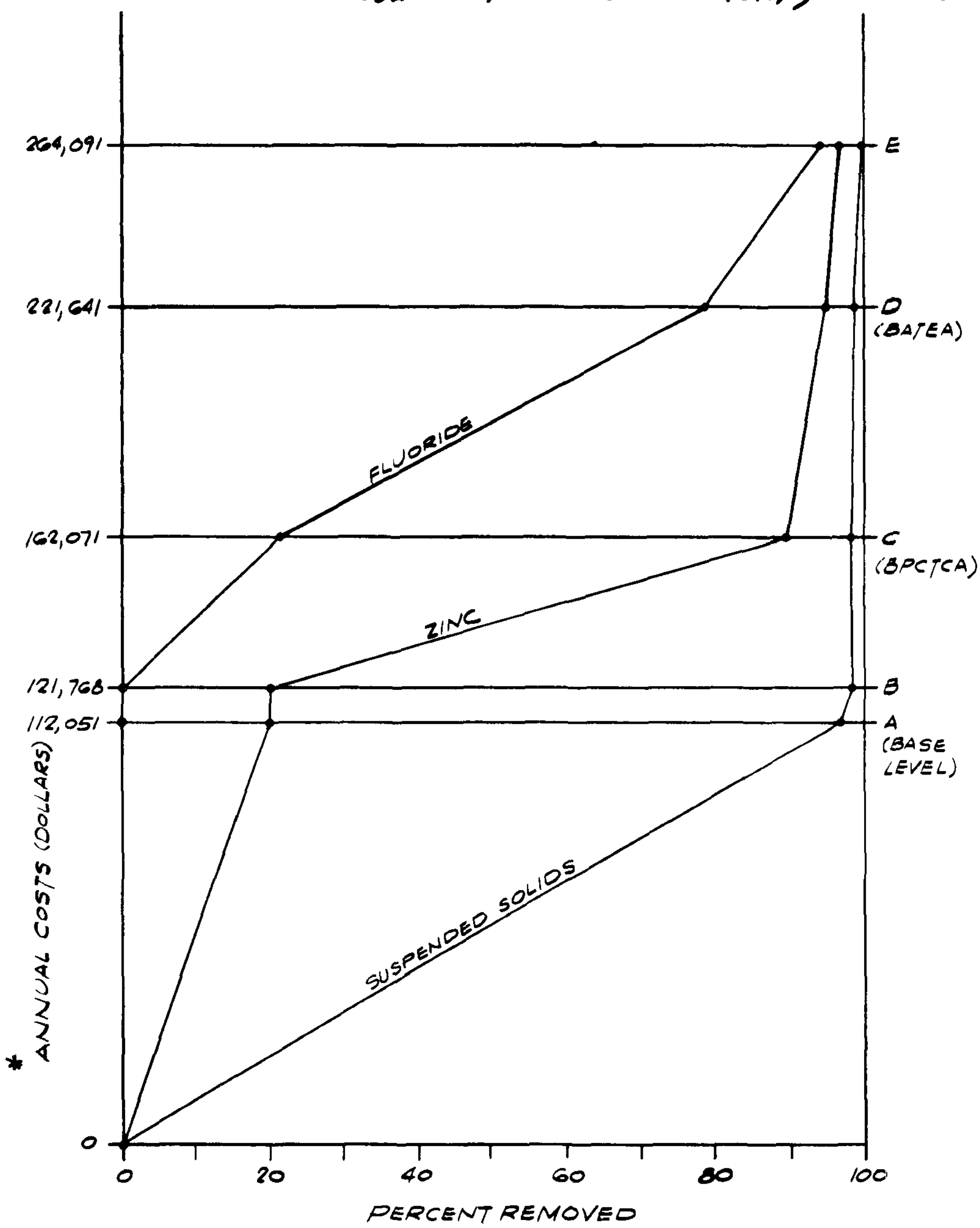
FIGURE 81B

MODEL COST EFFECTIVENESS DIAGRAM
ELECTRIC ARC FURNACE
(WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 1652 KKG/DAY (1820 TON/DAY) EAF SHOP



Although the effluent analyses from the two plants surveyed indicated no significant amount of zinc present, an effluent guideline similar to that established for the open hearth has been recommended since galvanized scrap can be an even greater proportion of the charge to an electric furnace than to an open hearth furnace.

Vacuum Degassing Subcategory

The direct contact process water used in vacuum degassing is the cooling water used for the steam-jet ejector barometric condensers. All vacuum systems draw their vacuum through the use of steam ejectors. As the water rate depends upon the steaming rate and the number of stages used in the steam ejector, the process flow rates can vary considerably. Two degassing plants were surveyed and each had a water treatment system which treated other steelmaking operation proces waste waters as well; i.e. one with a continuous casting water treatment system and the other with BOF discharges. The water systems were recirculating The blowdown rates varied from 45.5 l/kkg (10.9 gal/ton) to 66.7 l/kkg (16.0 gal/ton) and) and represented from 2% to 5% of the process recycle rate, respectively. The ELG's were established on the basis of 104 l/kkg (25 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. The value of 104 l/kkg (25 gal/ton) has been set somewhat higher than the measured values to compensate for the anticipated increased flows that would be achieved if the systems were joined with other steelmaking processes in which more heat is generated.

A review of the data collected resulted in the following effluent guidelines:

Zinc

Zinc was measured at 0.9 and 416 mg/l, respectively, at the two plants surveyed. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for zinc removal. The latter plant also displayed a very high level of effluent suspended solids (1077 mg/l) which would account for the high zinc concentration if most of the zinc is in the particulate form. As indicated under the subcategory for open hearths, the BATEA guideline is based on 5 mg/l measured in 104 l/kkg (25 gal/ton) in this instance. Discussion of the removal techniques will be deferred to the section dealing with suspended solids.

Manganese

For the two plants surveyed, the effluent manganese concentrations were measured at 2.8 and 340 mg/l. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for manganese removal. The BATEA guideline for manganese is based on 5 mg/l measured in 104 l/kkg (25 gal/ton). Discussion of the removal

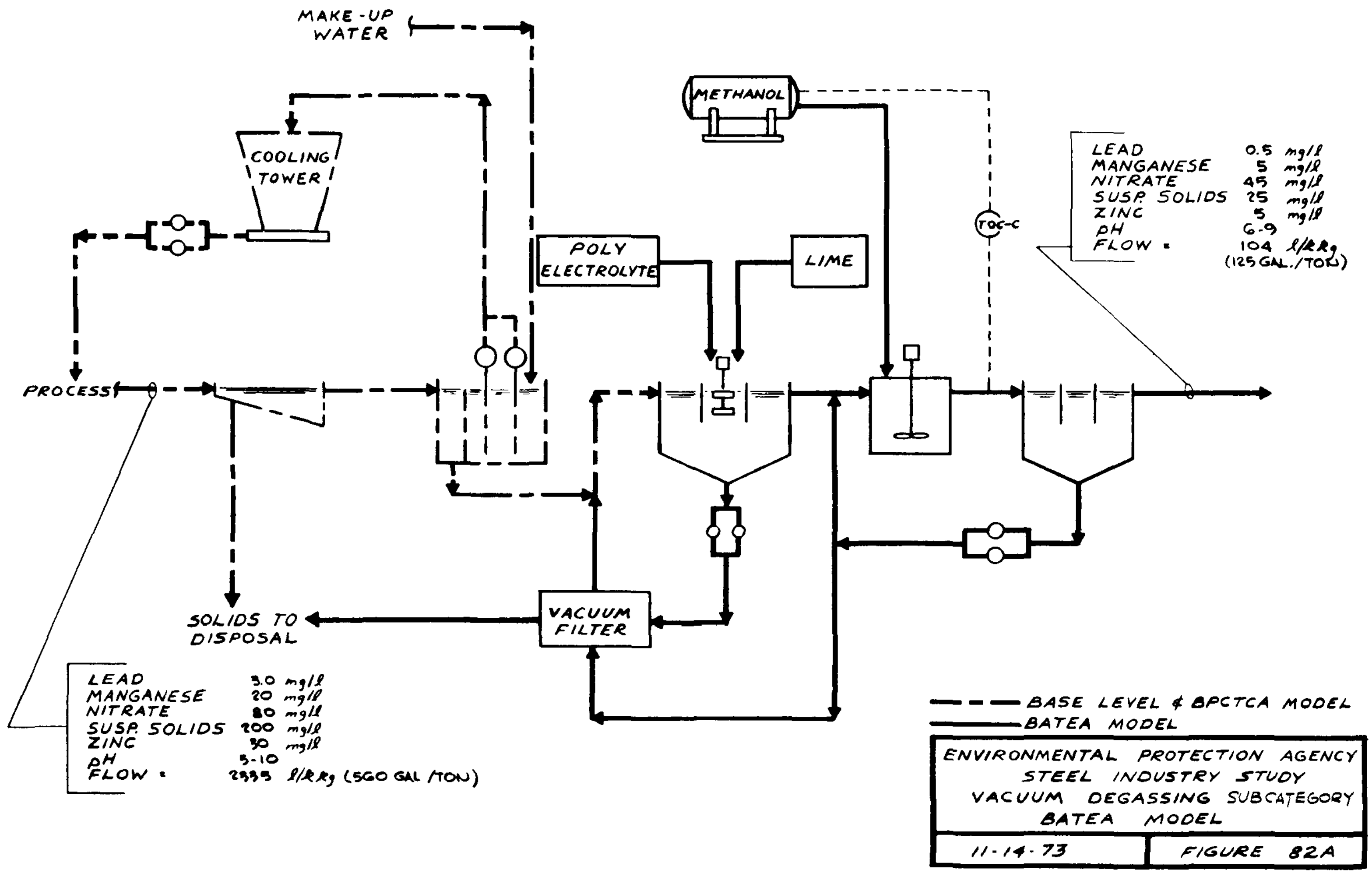
TABLE 87

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Vacuum Degassing

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg (1) (LB/1000 LB)	mg/l (2)	CONTROL & TREATMENT TECHNOLOGY (3)	ESTIMATED (4) TOTAL COST $/KKg	$/TON
Suspended Solids	0.0026	25			
Zinc	0.00052	5			
Manganese	0.00052	5	Blowdown treatment with sand filtration		
Lead	0.00005	0.5			
Nitrate (as NO_3)	0.0047	45	Blowdown treatment with anaerobic denitrification, (or substitution of another gas for blanketing instead of nitrogen)	0.492	0.446
pH	6.0 - 9.0		Neutralization		
Flow	Most probable value for tight system is 104 liters effluent per kkg of steel degassed (25 gal/ton) (excluding all non-contact cooling water)				

(1) Kilograms per metric ton of steel degassed, or pounds per 1000 pounds of steel degassed.
(2) Milligrams per liter based on 104 liters effluent per kkg of steel degassed (25 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.



MAKE-UP WATER
COOLING TOWER
METHANOL
POLY ELECTROLYTE
LIME
TOC-C
PROCESS
SOLIDS TO DISPOSAL
VACUUM FILTER
LEAD 0.5 mg/l
MANGANESE 5 mg/l
NITRATE 45 mg/l
SUSP. SOLIDS 25 mg/l
ZINC 5 mg/l
pH 6-9
FLOW = 104 l/kkg (125 GAL./TON)
LEAD 3.0 mg/l
MANGANESE 20 mg/l
NITRATE 80 mg/l
SUSP. SOLIDS 200 mg/l
ZINC 30 mg/l
pH 5-10
FLOW = 2335 l/kkg (560 GAL/TON)
BASE LEVEL & BPCTCA MODEL
BATEA MODEL
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSING SUBCATEGORY
BATEA MODEL
11-14-73
FIGURE 82A

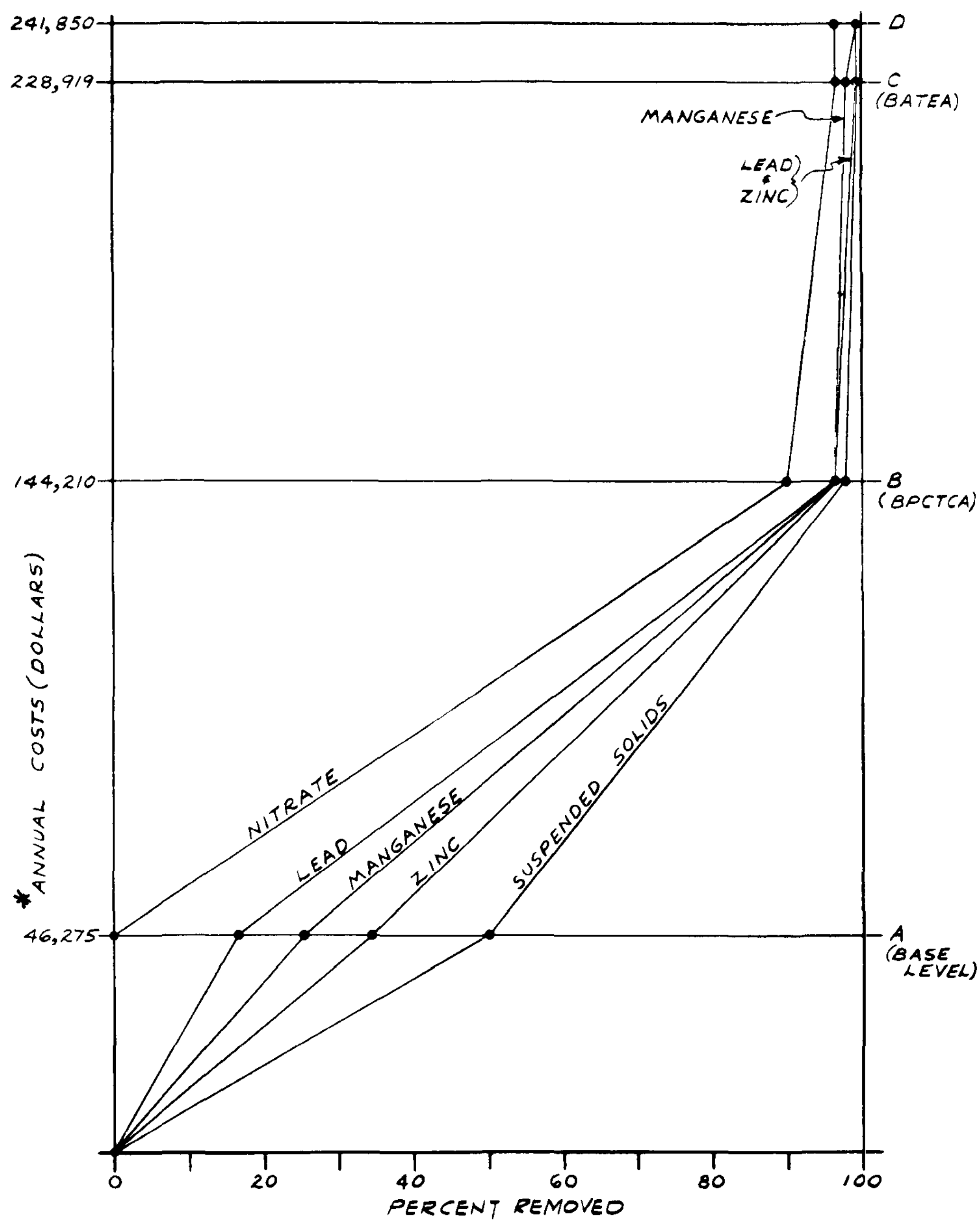
FIGURE 82B

MODEL COST EFFECTIVENESS DIAGRAM
VACUUM DEGASSING SUBCATEGORY

*ANNUAL COST = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

* COST BASED ON 472 KKG/DAY (520 TON/DAY) VACUUM DEGASSING OPERATION



techniques will be deferred to the section dealing with suspended solids.

Lead

The two plants surveyed showed lead concentrations of less than 0.1 and 32 mg/l, respectively, in their final effluents. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for lead removal. The BATEA guideline for lead is based on 0.5 mg/l measured in 104 l/kkg (25 gal/ton). Discussion of the removal techniques will be deferred to the section dealing with suspended solids.

Suspended Solids

For the two plants surveyed, the suspended solids in the final effluent were found to be 37 and 1077 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for suspended solids removal. The plant achieving the suspended solids level of 37 mg/l was also the plant obtaining low values for zinc, manganese and lead at 0.9, 2.8 and 0.1, respectively. This plant was using high rate pressure sand filtration on the final effluent prior to discharge. Furthermore, the effluent from the sand filter was actually achieving 75% of all the above constituent levels reported, but these levels were adjusted upward to compensate for removal of the other process waters not related to vacuum degassing. The BATEA guidelines for suspended solids is based on 25 mg/l measured in 104 l/kkg (25 gal/ton). It should be noted that a plant using sand filtration can readily achieve these levels and furthermore this technology also removes the zinc, manganese, and lead to BATEA guidelines previously recommended. An alternate technology for removal of these critical parameters to the indicated levels would be coagulation techniques. Table 87 is referred to for a summary of indicated ELG's and suggested technologies.

Nitrate

For the two plants surveyed, nitrate was found to be 0 and 1940 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for nitrate removal. For the reasons previously established for the open hearth, the ELG for nitrate should be based on 45 mg/l at 104 l/kkg (25 gal/ton) in this case. The technology for achieving this level is shown in Table 87 and is discussed in detail under the open hearth subcategory.

pH

The pH of the two plants surveyed was found to vary between 6.2 and 7.7 which is within the recommended BPCTCA range of 6.0 to 9.0. The BATEA guideline for pH remains at this level, as for all other subcategories.

It should be noted that many of the aforementioned critical parameters observed in the final effluent are the apparent result of various alloying agents being added to the steel during the steelmaking process. The nitrates found may be coming from nitrogen gas which is commonly used for blanketing to insure no explosions take place.

Continuous Casting Subcategory

The only process waters used in the continuous casting process are direct contact cooling water sprays which cool the cast product as it emerges from the molds. The water treatment methods used are either recycle flat bed filtration for removal of suspended solids and oils or scale pits with recirculating pumps. Both systems require blowdown. The flat bed filters remove oil and suspended solids whereas the scale pits may require ancilliary oil removal devices.

Two continuous casting plants were surveyed. One plant had a scale pit with sand filters with blowdown while the other plant had flat bed filters with blowdown. Both had cooling towers for cooling the spray water before recycling to the caster. The blowdown varied between 342 l/kkg (82 gal/ton) and 463 l/kkg (111 gal/ton). The ELG's were therefore established on the basis of 521 l/kkg (125 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The plant employing the flat bed filter system was achieving 4.4 mg/l suspended solids in the treated effluent; whereas the plant utilizing the pressure sand filters was obtaining only 37 mg/l in the final treated effluent. An apparent anomaly existed here, since deep bed sand filters normally achieve higher quality of effluents than flat bed filters. It was later discovered that the plant using the pressure sand filters was continually backwashing one of the dirty filters into the final treated effluent. This plant was judged inadequate with respect to applying good engineering design to alleviate the problem of contaminating the treated effluent with filter backwash. By correcting this problem, this plant should have no trouble obtaining 10 mg/l or less suspended solids in the filtrate. Since the flat bed system was already achieving less than this value, the BATEA ELG for suspended solids has been based on 10 mg/l at 521 l/kkg (125 gal/ton).

Oil and Grease

The two plants surveyed were achieving excellent reductions in oil and grease as an apparent result of removal in the filtering devices. The two plants combined averaged less than 2.4 mg/l oil in the final effluent. However, the BATEA for oil and grease has been based on 10 mg/l at 520 l/kkg (125 gal/ton) for the reasons indicated above for the

TABLE 88

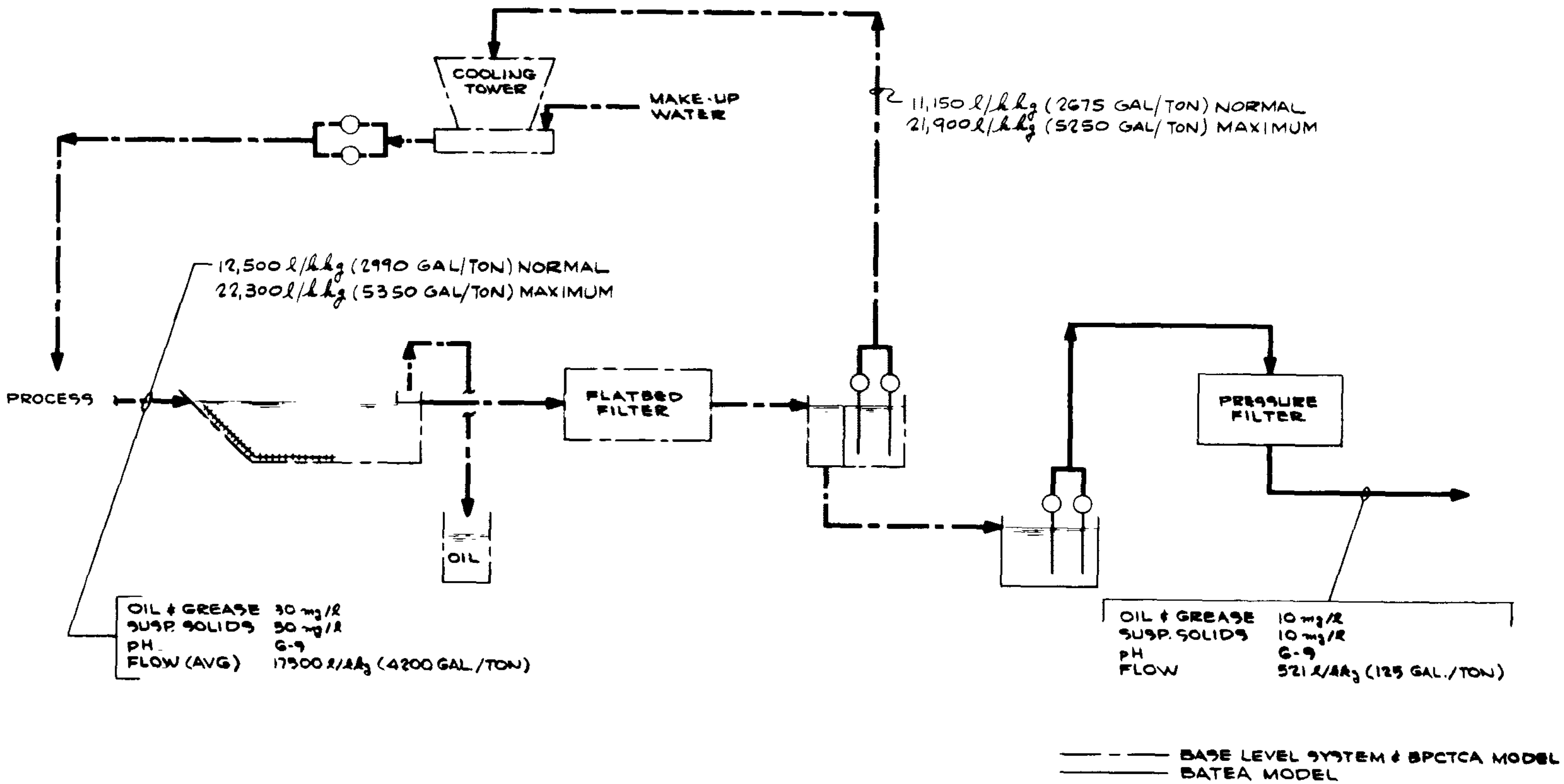
BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Continuous Casting

CRITICAL PARAMETERS	BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB)	mg/l[2]	CONTROL & TREATMENT TECHNOLOGY[3]	ESTIMATED[4] TOTAL COST $/KKg	$/TON
Suspended Solids	0.0052	10	BPCTCA plus: Filtration of blowdown.	0.0752	0.0682
Oil and Grease	0.0052	10			
pH	6.0 - 9.0				

Flow: Most probable value for tight system is 522 liters effluent per kkg of steel cast (125 gal/ton) (excluding all non-contact cooling water).

(1) Kilograms per metric ton of steel cast, or pounds per 1000 pounds of steel cast.
(2) Milligrams per liter based on 522 liters effluent per kkg of steel cast (125 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a pland and/or have been installed as a result of complying with BPCTCA Standards.



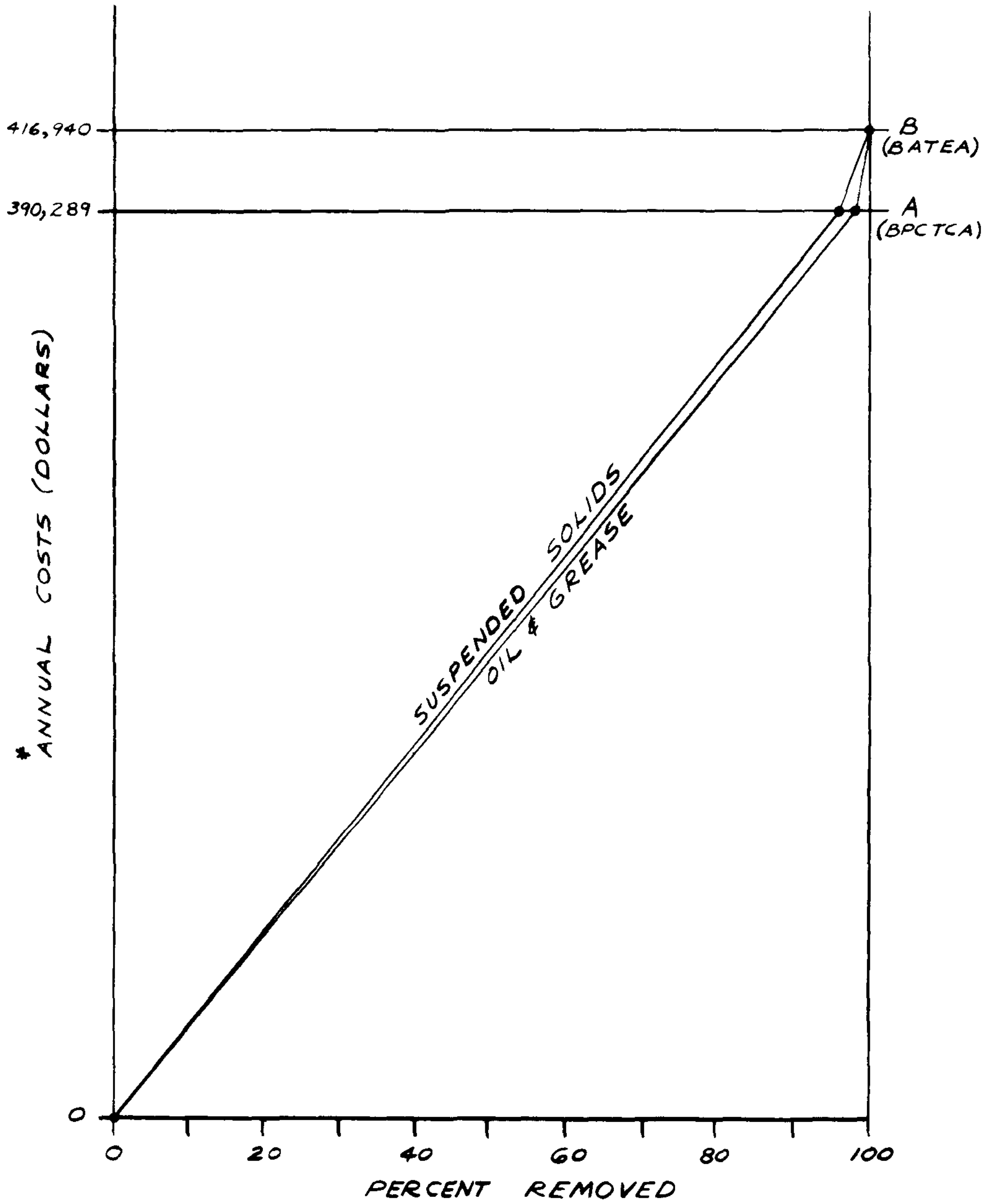
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
CONTINUOUS CASTING SUBCATEGORY
BATEA MODEL

11-15-79 | FIGURE 83A

FIGURE 83B

MODEL COST EFFECTIVENESS DIAGRAM
CONTINUOUS CASTING SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 971 KKG/DAY (1070 TON/DAY) CONTINUOUS CASTING OPERATION



By Product Coke subcategory. Table 88 summarizes the indicated technology.

pH

The pH for the two plants surveyed varied between 6.8 and 7.7 which is within the range of 6.0 to 9.0 established as the BPCTCA guideline. No further tightening of the BOCTCA guideline is recommended at this time.

Treatment Models

Treatment models of systems to achieve the effluent quality proposed for each subcategory have been developed. Sketches of the BATEA models are presented in Figures 72A through 83A. The development included not only a determination that a treatment facility of the type developed for each subcategory could achieve the effluent quality proposed but it included a determination of the capital investment and the total annual operating costs for the average size facility. In all subcategories, these models are based on the combination of process changes and unit (waste treatment) operations in an "add-on" fashion as required to control the significant waste parameters. The process changes and the unit operations were each selected as the least expensive means to accomplish their particular function and thus their combination into a treatment model presents the least expensive method for control for a given subcategory.

Alternate treatment methods could be insignificantly more effective and would be more expensive. In only one subcategory, Coke Making-By Product, was an alternate developed to provide an option for high capital investment and low operating cost as compared to the low capital investment high operating costs that are inherent in the basic treatment model. However, the alternate relies on the use of treatment technology that has been developed only to the pilot stage or as steps utilized individually, but not in the combination required in this model on this type of waste on a full scale basis. Therefore, the effluent limitation and treatment costs have been developed via the basic treatment model rather than the alternate.

Cost Effectiveness Diagrams

Cost effectiveness diagrams (Figures 72B through 83B) have been included to show the costs of waste reduction in relation to the percent reduction achieved by the various treatment models presented in Tables 54 through 64. These treatment models are combinations of the "least cost" process changes and unit (waste treatment) operations to achieve a given effluent quality. Alternate models could be developed and costed out but they would by definition be more costly and not significantly more effective.

The cost effectiveness diagrams must be intrepreted with caution in that they can be misleading in at least two ways. While percent reduction is plotted, the real objective is to achieve the effluent quality attainable with the application of the best practicable control technology currently available or the best available technology economically achievable. Some industrial wastes contain very high concentrations of pollutants and a treatment system which achieves a 95 percent reduction may still produce an effluent with a high concentration of the pollutant remaining, i.e. a concentration that can be further reduced at an economically acceptable cost. However, economics has dicated that the application of some treatment technologies be deferred until 1983 and that some high concentrations of pollutants, representing a low percentage of the initial load, be tolerated in the interim.

As an example of the significance of concentration rather than percent reduction as a factor to be considered in determining whether the additional treatment costs can be justified by the added treatment achieved, Figure 76 B presents a good example. While the recycle system (Model B) reduced the effluent volume and effluent load, the effect is to concentrate the cyanides such that the cyanide concentration in the blowdown stream to discharge is 30 mg/l. This is a concentration that can readily be reduced by treatment technology in a cost effective manner. Therefore treatment of this blowdown stream has been proposed as BATEA.

The cost effectiveness diagrams can also be misleading in that the added cost to get from one model to the next cannot be attributed in part to each of the reductions that occur. Figure 72B is a good example. The costs to get from Model B to Model C(BATEA) is primarily associated with the chlorination to reduce the cyanide concentration and adsorption of the chlorinated organics with some small part of the cost for sulfide reduction and neutralization. However, reductions in the other parameters occur as a side effect of the treatment steps added. Though the reduction in phenol is small and may not justify further expenditures for this purpose, in actuality none of the added cost is attributable to this. The diagram shows a great percentage reduction in suspended solids but this is actually a small reduction in a parameter that is not present to a great extent to begin with. And the reduction is not primarily to achieve solids reduction for effluent quality purposes but to prevent plugging of the carbon adsorption system that follows.

The regulations proposed herein apply only to the process waste waters of the raw steel making operations. The Phase II study of the forming and finishing operations as well as the foundry industry is underway and is expected to be completed in the spring of 1974. This phase will consider thermal limitations on the process and noncontact cooling waters of all operations in the industry.

The costs and methods for fugitive runoff controls for the raw steel making operations have already been developed but action on this has been deferred until the total water pollution control costs for all operations has been developed.

Cost to the Iron and Steel Industry

Table 89 presents a summary of projected capital and annual operating costs to the integrated mills of the steel industry as a whole to achieve the effluent quality proposed herein for BPCTCA and BATEA for the steel making operations.

The Total annual costs (including amortization) for the BPCTCA and BATEA regulations proposed herein are estimated at $82.3 million or 0.37% of the 1972 gross revenue of the steel industry. This is an addition to the $127 million annual capital amortization and operating costs, (0.56% of 1972 gross revenue) which we estimate the industry is already spending on these operations. The total estimated costs for water pollution control will be available only after the Phase II study is completed. However, the preliminary estimate is that the additional annual costs (including amortization) for the remaining forming and finishing operations, for thermal limitations, and for fugitive runoff controls will be approximately three to four times those proposed herein for the steel making operations or $295 million per year. Total annual costs (including amortization) for water pollution controls after 1983, including operation and amortization of existing facilities, are estimated at %551 million or 2.45% of the 1972 gross revenue. Of this amount, 377 million (or 1.68%) will be incremental to the current rate of expenditures.

As presented in the table, an initial capital investment of approximately $144.9 million with annual capital and operating costs of $39.9 million would be required by the industry to achieve BPCTCA guidelines. An additional capital investment of approximately $122.3 million and a total annual capital amortization and operating cost of $82.3 million would be needed to achieve BATEA guidelines. Costs may vary depending upon such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and the extent of preliminary modifications required to accept the necessary control and treatment devices.

The operating costs (including amortization) for air pollution controls for the steel industry, as presented in the Council on Environmental Quality report of March, 1972 titled "Economic Impact of Pollution Control - A Summary of Recent Studies" shows costs building up to $693 million dollars per year for 1976. This is equivalent to 3.08% of the 1972 gross revenue of the industry.

TABLE 89
IRON AND STEELMAKING OPERATIONS
PROJECT TOTAL COSTS FOR RELATED SUBCATEGORIES

			COSTS TO INDUSTRY (1)			
			BPCTCA		BATEA	
Subcategory	1972 Annual Production (millions of tons)	Number of Plants	Annual Capital and Operating Cost	Initial Capital Investment	Annual Capital and Operating Cost	Initial Capital Investment
Coke Making						
By Product	64.2	66	10,034,000	11,118,000	23,538,000 (2)	61,732,000
Beehive	0.8	3	38,000	152,000	38,000	0
Burden Preparation						
Sintering	6.5	6	335,000	1,530,000	746,000	1,765,000
Iron Making						
Blast Furnace - Fe	82.1	68	20,169,000	100,414,000	40,021,000	28,086,000
Blast Furnace - FeMn	0.9	3	1,059,000	5,177,000	2,629,000	963,000
Steelmaking						
BOF (Semi-wet)	17.8	10	390,000	1,875,000	390,000	0
BOF (wet)	47.1	17	3,884,000	7,895,000	5,286,000	6,175,000
OH (wet)	13.5	5	746,000	2,665,000	2,290,000	7,837,000
EF (semi-wet)	1.2	2	0	0	0	0
EF (wet)	5.3	8	400,000	1,776,000	877,000	2,289,000
Degassing	5.5	29	2,840,000	12,290,000	5,297,000	8,908,000
Continuous Casting	18.0	46	0	0	1,226,000	4,562,000
TOTAL			39,895,000	144,892,000	82,338,000	122,317,000

(1) Costs determined by following relationships:
(a) Annual capital + operating = Number of plants x annual cost/facility
(b) Initial capital investment = number of plants x 1st cost/facility

(2) Does not include the $10,034,000 for BPCTCA since BATEA is achieved by switching to a multi-stage biological treatment facility.

The total annual costs (including amortization) for air and water pollution controls for all operations of the stell industry is thus estimated at 1.24 billion per year after 1983 or 5.54% of gross revenues for 1972. This includes the 292 million or 1.3% of gross revenues for 1972 which it is estimated that the industry is currently spending annually for air and water pollution controls.

Economic Impact

The economic impact of these proposed BPCTCA and BATEA Limitations is discussed in a report titled *Economic Analysis of the Proposed Effluent Guidelines for the Integrated Iron and Steel Industry* (January 1974) which was prepared for the Environmental Protection Agency by A. T. Kearney and Company, Inc., Chicago, Illinois.

SECTION XI

EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF NEW SOURCE PERFORMANCE STANDARDS

Introduction

The Best Available Demonstrated Control Technology (BADCT) is to be achieved by "New Sources". "New Sources" has been defined as any source the construction of which is commenced after the publication of the proposed regulations. The BADCT technology is that level which can be achieved by adding to the BATEA technology improved production processes and/or treatment techniques. For purposes of developing the BPCTCA and BATEA technologies and limitations, the industry was divided into the following subcategories:

I By Product Coke Subcategory

II Beehive Coke Subcategory

III Sintering Subcategory

IV Blast Furnace (Iron) Subcategory

V Blast Furnace (Ferromanganese) Subcategory

VI Basic Oxygen Furnace (Semi Wet Air Pollution Control Methods) Subcategory

VII Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

VIII Open Hearth Furnace Subcategory

IX Electric Arc Furnace (Semi Wet Air Pollution Control Methods) Subcategory

X Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

XI Vacuum Degassing Subcategory

XII Continuous Casting Subcategory

By Product Coke Subcategory

In by-product coke making, the process wastewater resulting from the production of coke is 80 to 165 liters/kkg (19 to 40 gal/ton) of coke produced. This water is actually produced as a result of coking the coal, and represents the water present in the raw coal which was placed in the ovens. This water leaves the ovens in the gas and is condensed out of the gas at two points in the system, the primary cooler and the final cooler. Approximately 75% of the total volume comes out in the primary cooler and is called ammonia liquor. The remaining 25% comes out into the final cooler and is generally referred to as final cooler drains.

Water in excess of this approximately 104 l/kkg (25 gal/ton) which shows up in the effluent from a coke plant is added to the system to aid in processing of the coke or the by-products. Other sources of water in coke plant wastes are coke quenching tower overflow (or blowdown), coke wharf drains, steam condensed in the ammonia stills, cooling tower, and boiler blowdowns, cooling system leaks, general washwater used in the coke plant area, and dilution water used to lower pollutant concentrations for biological treatment.

Any process which brings about the pyrolytic decomposition of coal will of necessity have 80 to 165 liters/kkg (19 to 40 gal/ton) of highly contaminated liquid to dispose of. The coke wharf and quenching water can be eliminated by dry coke quenching which is presently being practiced in other countries or simply by routing the wharf drains to the quench tower as make-up water, and not allowing any overflow from the quench tower. Operating a quench tower with no overflow may generate some heat and corrosion problems, but these can be eliminated with conventional designs.

If no liquid discharge is to be achieved from modern coke plants, a means of total disposal must be found for the 80 to 165 liters/kkg (19 to 40 gal/ton) of liquid which of necessity is produced. All of the wastes in this water, with the possible exception of suspended solids, are subject to pyrolytic decomposition. A rough estimate shows that about 126,000 kilogram calories per metric ton of coke produced would be required to dispose of this waste. This is a negligible percentage of the fuel value of the tar and gas generated in the production of a ton of coke.

However, there is reason to believe that unless very sophisticated means were used to pyrolytically dispose of this water, serious air pollution problems would result. The effluent gases from less than optimum incineration of this water could be expected to contain high concentrations of NOX, SOX, and some particulate matter. If a simple incinerator with a wet scrubber were used, the basic pollutants would simply be transferred back to another water stream possibly of larger volume than the original.

Since the pollutants in the liquid stream are essentially volatile, evaporation of the liquid to dryness would result in much the same problems as incineration. In fact, examination of numerous other points of disposal of this stream within an integrated steel mill all yield the same answer. While total pyrolytic decomposition of this small stream of waste to innocuous gases would be the most desirable method of disposal, present technology does not make this possible on a proven full-scale basis.

For the above reasons, NSPS limitations cannot be set at "no liquid discharge" until such time as technology becomes available for the total conversion of this waste stream into non-polluting substances. Therefore, the NSPS guidelines shall be the same as the BATEA guidelines for by products coke subcategory. Refer to Section X.

Sintering Subcategory

Burden preparation in an integrated steel mill generally takes the form of a sinter plant. The purpose of this plant is to recover fine raw materials and to agglomerate them into larger size pieces so that they can be charged into the blast furnace. In the manufacture of coke, fines are generated which must be screened out of the coke before it can be used in the blast furnace. The fines serve as the fuel for the sinter plant. The blast furnaces and steelmaking processes generate sizable quantities of fine dust which is high in iron content. It is this dust which is agglomerated in a sinter or pellet plant so that it can be recharged to the blast furnace.

It is possible to build a sinter plant with no liquid discharge. In fact, in past years, most sinter plants had no liquid discharge. As the requirements of higher air standards took effect, it became apparent that the conventional dry dust collection methods employed in older sinter plants were not adequate. In order to meet these higher standards, wet scrubbing of the dust laden gases came into being and thus a liquid discharge was generated.

This now becomes a situation of compromise and technology advancement. In order to achieve a "no liquid discharge" level for a sinter or pellet plant, the requirements of air quality and level of technology of dry dust collection must become coincidental. So long as air quality standards are such that they can only be met by wet scrubbing methods, there will be a liquid discharge from sinter plants. To simply abandon this practice of recovering valuable fines for reuse would be both costly to the industry and wasteful of natural resources. Since BATEA guidelines discussed in Section X represent the best available technology, this level must also be set for NSPS until such time as the technology of dry dust collection advances to the point where it can be used to achieve the required air quality standards.

NSPS Discharge Standard - Refer to BATEA for the Sintering Subcategory

Blast Furnace (Iron) and Blast Furnace (Ferromanganese) Subcategories

The primary liquid discharge from a blast furnace is made up of two parts, non-contact cooling water, and process water from gas cleaning operations. The non-contact cooling water should contain only heat, and no other pollutants contributed by the process. The heat added to the cooling water must be rejected to the environment in order for the process to operate. It can be rejected either to local streams or lakes by a once through cooling system or to the air by means of a cooling tower. Designs to achieve either means of rejection are quite standard and do not require further discussion.

The process water which is used to clean and cool the blast furnace top gas by direct contact with the gas becomes quite contaminated with suspended solids, cyanides, phenol, ammonia, and sulfides.

Modern blast furnace practice has shown that this gas cleaning and cooling water can be recycled. Normally the water would be put through settling chambers to remove the suspended solids and over a cooling tower to remove the heat.

While much effort has been expended to close these systems up completely and thereby produce a zero liquid discharge, it has not been clearly demonstrated that these systems can operate without some blowdown. For this reason, no additional reductions in pollutant loads from those described as BATEA limitations is proposed for NSPS, in either of the two blast furnace subcategories. Flows for ferromanganese operations remain at twice the recommended level for iron making furnaces. A detailed description or appropriate ELG for both subcategories is found in Section X.

NSPS Discharge Standard - Refer to BATEA for the Two Blast Furnace Subcategories

Steelmaking Operations

As is the case with the sinter plant, the liquid discharge exclusive of non-contact cooling water for all of the conventional steelmaking processes, open hearths, oxygen processes, electric furnaces, results from gas cleaning operations. Early gas cleaning systems on steelmaking processes were of the dry type, but the need to meet higher air quality standards has resulted in a shift on newer installations to wet cleaning methods. So long as the technology of dry gas cleaning lags behind the requirements for gas cleanliness, liquid discharges from steelmaking will continue. For this reason, no additional reductions in flow or pollutant loads from any steel making subcategory is proposed at this time as a new source performance standard. A detailed description of appropriate ELG's for all five steel making subcategories is found in Section X.

NSPS Discharge Standard - Refer to BATEA for the Five Steel Making Subcategories

Vacuum Degassing Subcategory

This relatively new steel process removes dissolved gases from the molten metal to improve its quality. Exclusive of non-contact cooling water, the liquid discharge from this process results from the condensation of steam used in the steam jet ejectors which pull the vacuum. High capacity ejectors capable of pulling a significant vacuum are used.

All of the removed gases plus any particulate matter which results from the violent boiling which occurs when the vacuum is drawn, come in contact with the water. This results in particulate and dissolved contamination of the condensate. which is produced in each of the interstage condensers. Substitution of another type of vacuum producing equipment does not seem practical at this time. No further reductions in recommended BATEA limitations are proposed.

NSPS Discharge Standard - Refer to BATEA for Vacuum Degassing Subcategory

Continuous Casting Subcategory

The continuous casting process in addition to non-contact cooling water, uses considerable quantities of contact cooling water. This water becomes contaminated primarily with small particles of iron oxide (suspended solids) and also picks up some small amount of oil and grease from the lubricants used on the equipment. Occasionally if there is a hydraulic leak, some hydraulic fluid will also get into this water. This contact cooling water is a basic part of this new process, and methods for materially reducing either the volume or the level of contamination are not available at this time. No further reductions in recommended BATEA limitations are proposed.

NSPS Discharge Standard - Refer to BATEA for Continuous Casting Subcategory.

SECTION XII

ACKNOWLEDGEMENTS

This report was prepared by the EPA on the basis of an industry study performed by the Cyrus Wm. Rice Division of NUS Corporation under Contract #68-01-1507. The RICE operations are based in Pittsburgh, Pennsylvania.

The preparation and writing of this document was accomplished by Mr. Edward L. Dulaney, Project Officer, EPA, and through the efforts of Mr. Thomas J. Centi Project Manager, Mr. Wayne M. Neeley, Mr. Patrick C. Falvey, Mr. David F. Peck, and Mr. Joseph C. Troy who prepared the orginal Rice study report to the EPA.

Field and sampling programs were conducted under the leadership of Mr. Donald J. Motz, Mr. Joseph A. Boros, and Mr. John D. Robins.

Laboratory and analytical services were conducted under the guidance of Mr. Paul Goldstein and Miss Ellen C. Gonter.

The many excellent Figures contained within were provided by the RICE drafting room under the supervision of Mr. Albert M. Finke. The work associated with the calculations of raw waste loads, effluent loads, and costs associated with treatment levels is attributed to Mr. William C. Porzio, Mr. Michael E. Hurst, and Mr. David A. Crosbie.

The excellent guidance provided by Mr. Walter J. Hunt, Chief, Effluent Guidelines Development Branch, OAWP, Environmental Protection Agency is acknowledged with grateful appreciation.

The cooperation of the individual steel companies who offered their plants for survey and contributed pertinent data is gratefully appreciated. The operations and the plants visited were the property of the following companies: Jones & Laughlin Steel Corporation, Bethlehem Steel Corporation, Inland Steel Company, Donner Hanna Coke Corporation, Interlake, Inc., Wisconsin Steel Division of International Harvester Company, Jewell Smokeless Coal Corporation, Carpentertown Coal and Coke Company, Armco Steel Corporation, National Steel Corporation, United States Steel Corporation, and Kaiser Steel Corporation.

The assistance of steel industry consultants, namely Ramseyer and Miller, Ferro-Tech Industries, and Deci Corporation was utilized in several areas of the project.

Acknowledgement and appreciation is also given to Dr. Chester Rhines for technical assistance, to Ms. Kit Krickenberger for invaluable support in coordinating the preparation and reproduction of this report, to Ms. Kay Starr, Ms. Nancy Zrubek and Ms. Chris Miller of the EGD secretarial staff, Mrs. Minnie C. Harold, for library assistance and to Mrs. Carol Iannuzzi, Mrs. Pat Nigro, and Mrs. Mary Lou Simpson, of the RICE Division for their efforts in the typing of drafts, necessary revisions, and final preparation of the original Rice effluent guidelines document and revisions.

SECTION XIII

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SECTION XIV

GLOSSARY

Acid Furnace

A furnace lined with acid brick as contrasted to one lined with basic brick. In this instance the terms acid and basic are in the same relationship as the acid anhydride and basic anhydride that are found in aqueous chemistry. The most common acid brick is silica brick or chrome brick.

Air Cooled Slag

Slag which is cooled slowly in large pits in the ground. Light water sprays are generally used to accelerate the cooling over that which would occur in air alone. The finished slag is generally gray in color and looks like a sponge.

Alloying Materials

Additives to steelmaking processes producing alloy steel.

Ammonia Liquor

Primarily water condensed from the coke oven gas, an aqueous solution of ammonium salts of which there are two kinds-free and fixed. The free salts are those which are decomposed on boiling to liberate ammonia. The fixed salts are those which require boiling with an alkali such as lime to liberate the ammonia.

Ammonia Still

The free ammonia still is simply a steam stripping operation where ammonia gas is removed from ammonia liquor. The fixed still is similar except lime is added to the liquor to force the combined ammonia out of its compounds so it can be steam stripped also.

Ammonia Still Waste

Treated effluent from an ammonia still.

Apron Rolls

Rolls used in the casting strand for keeping cast products aligned.

Basic Brick

A brick made of a material which is a basic anhydride such as MgO or mixed MgO plus CaO. See acid furnace.

Basic Furnace

A furnace in which the refractory material is composed of dolomite or magnesite.

Basic Oxygen Steelmaking

The basic oxygen process is carried out in a basic lined furnace which is shaped like a pear. High pressure oxygen is blown vertically downward on the surface of the molten iron through a water cooled lance.

Battery

A group of coke ovens arranged side by side.

Blast Furnace

A large, tall conical shaped furnace used to reduce iron ore to iron.

Bosh

The bottom sect!on of a blast furnace. The section between the hearth and the stack.

Briquette

An agglomeration of steel plant waste material of sufficient strength to be a satisfactory blast furnace charge.

By-Product Coke Process

Process in which coal is carbonized in the absence of air to permit recovery of the volatile compounds and produce coke.

Burden

Solid feed stack to a blast furnace.

Carbon Steel

Steel which owes its properties chiefly to various percentages of carbon without substantial amounts of other alloying elements. Steel is classified as carbon steel when no minimum content of elements other than carbon is specified or required to obtain a desired alloying effect.

Charge

The minimum combination of skip or bucket loads of material which together provide the balanced complement necessary to produce hot metal of the desired specification.

Checker

A regenerator brick chamber which is used to absorb heat and cool the waste gases to 650-750°C.

Cinder

Another name for slag.

Clarification

The process of removing undissolved materials from a liquid, specifically either by settling or filtration.

Closed Hood

A system in which the hot gases from the basic oxygen furnace are not allowed to burn in the hood with outside air infiltration. These hoods cap the furnace mouth.

Coke

The carbon residue left when the volatile matter is driven off of coal by high temperature distillation.

Coke Breeze

Small particles of coke; these are usually used in the coke plants as boiler feed or screened for domestic trade.

Coke Wharf

The place where coke is discharged from quench cars prior to screening.

Cold Metal Furnace

A furnace that is usually charged with two batches of solid material.

Continuous Casting

A new process for solidifying liquid steel in place of pouring it into ingot molds. In this process the solidified steel is in the form of cast blooms, billets, or slabs. This eliminates the need for soaking pits and primary rolling.

Creosote

Distillate from tar.

Dephenolizer

A facility in which phenol is removed from the ammonia liquor and recovers it as sodium phenolate; this is usually accomplished by liquid extraction and vapor recirculation.

Double Slagging

Process in which the first oxidizing slag is removed and replaced with a white, lime finishing slag.

Drags

Flat bed railroad cars. A drag will generally consist of five or six coupled cars.

Duplexing

An operation in which a lower grade of steel is produced in the basic oxygen furnace or open hearth and is then alloyed in the electric furnace.

Dustcatcher

A part of the blast furnace through which the major portion of the dust is removed by mechanical separation.

Electric Furnace

A furnace in which scrap iron, scrap steel, and other solid ferrous materials are melted and converted to finished steel. Liquid iron is rarely used in an electric furnace.

Electrostatic Precipitator

A gas cleaning device using the principle of placing an electrical charge on a solid particle which is then attracted to an oppositely charged collector plate. The collector plates are intermittently rapped to discharge the collected dust to a hopper below.

Evaporation Chamber

A method used for cooling gases to the precipitators in which an exact heat balance is maintained between water required and gas cooling; no effluent is discharged in this case as all of the water is evaporated.

Fettling

The period of time between tap and start.

Final Cooler

A hurdle packed tower that cools the coke oven gas by direct contact. The gas must be cooled to 30°C for recovery of light oil.

Flushing Liquor

Water recycled in the collecting main for the purpose of cooling the gas as it leaves the ovens.

Flux

Material added to a fusion process for the purpose of removing impurities from the hot metal.

Fourth Hole

A fourth refractory lined hole in the roof of the electric furnace which serves as an exhaust port.

Free Leg

A portion of the ammonia still from which ammonia, hydrogen sulfide, carbon dioxide, and hydrogen cyanide are steam distilled and returned to the gas stream.

Fugitive Emissions

Emissions that care expelled to the atmosphere in an uncontrolled manner.

Granulated Slag

A product made by dumping liquid blast furnace slag past a high pressure water jet and allowing it to fall into a pit of water. The material looks like light tan sand.

Hot Blast

The heated air stream blown into the bottom of a blast furnace. Temperatures are in the range of 550°C to 1000°C, and pressures are in the range of 2 to 4.5 atmospheres.

Hot Metal

Melted, liquid iron or steel. Generally refers to the liquid metal discharge from blast furnaces.

Hot Metal Furnace

A furnace that is initially charged with solid materials followed by a second charge of melted liquid.

Ingot

A large block shaped steel casting. Ingots are intermediates from which other steel products are made. An ingot is usually the first solid form the steel takes after it is made in a furnace.

Ingot Mold

A mold in which ingots are cast. Molds may be circular, square, or rectangular in shape, with walls of various thickness. Some molds are of larger cross section at the bottom, others are larger at the top.

Iron

The product made by the reduction of iron ore. Iron in the steel mill sense is impure and contains up to 4% dissolved carbon along with other impurities. See steel.

Iron Ore

The raw material from which iron is made. It is primarily iron oxide with impurities such as silica.

Kish

A graphite formed on hot metal following tapping.

Light Oil

A clear yellow-brown oil with a specific gravity of about 0.889. It contains varying amounts of coal-gas products with boiling points from about 40°C to 200°C and from which benzene, toluene, xylene and solvent napthas are recovered.

Lime Boil

The turbulence created by the release of carbon dioxide in the calcination of the limestone.

Lime Leg The fixed leg of the ammonia still to which milk of lime is added to decompose ammonium salts; the liberated ammonia is steam distilled and returned to the gas stream.

Meltdown

The melting of the scrap and other solid metallic elements of the charge.

Mill Scale

The iron oxide scale which breaks off of heated steel as it passes through a rolling mill. The outside of the piece of steel is generally completely coated with scale as a result of being heated in an oxidizing atmosphere.

Molten Metal Period

The period of time during the electric furnace steelmaking cycle when fluxes are added to furnace molten bath for forming the slag.

Open Hearth Furnace

A furnace used for making steel. It has a large flat saucer shaped hearth to hold the melted steel. Flames play over top of the steel and melt is primarily by radiation.

Open Plate Panel Hood

A 4.5 meter to 6 meter square, rectangular or circular cross sectional shaped conduit, open at both ends, which is used in the BOF steelmaking process for the combustion and conveyance of hot gases, fume, etc., which are generated in the basic oxygen furnace to the waste gas collection system.

Ore Boil

The generation of carbon monoxide by the oxidation of carbon.

Oxidizing Slags

Fluxing agents that are used to remove certain oxides such as silicon dioxide, manganese oxide, phosphorus pentoxide and iron oxide from the hot metal.

Pelletizing

The processing of dust from the steel furnaces into a pellet of uniform size and weight for recycle.

Pig Iron

Impure iron cast into the form of small blocks that weigh about 30 kilograms each. The blocks are called pits.

Pinch Rolls

Rolls used to regulate the speed of discharge of cast product from the molds.

Pitch

Distillate from tar.

Pouring

The transfer of molten metal from the ladle into ingot molds or other types of molds; for example, in castings.

Quenching

A process of rapid cooling from an elevated temperature by contact with liquids, gases, or solids.

Quench Tower

The station at which the incandescent coke in the coke car is sprayed with water to prevent combustion. Quenching of coke requires about 500 gallons of water per ton of coke.

Reducing Slag

Used in the electric furnace following the slagging off of an oxidizing slag to minimize the loss of alloys by oxidation.

Refining Oxidation cycle for transforming hot metal (iron) and other metallics into steel by removing elements present such as silicon, phosphorus, manganese and carbon.

Runner

A channel through which molten metal or slag is passed from one receptacle to another; in a casting mold, the portion of the gate assembly that connects the downgate or sprue with the casting.

Runout

Escape of molten metal from a furnace, mold or melting crucible.

Slag

A product resulting from the action of a flux on the nonmetallic constituents of a processed ore, or on the oxidized metallic constituents that are undesirable. Usually slags consist of combinations of acid oxides with basic oxides, and neutral oxides are added to aid fusibility.

Spark Box

A solids and water collection zone in a basic oxygen furnace hood.

Steel

Refined iron. Typical blast furnace iron has the following composition: Carbon - 3 to 4.5%; Silicon - 1 to 3%; Sulfur - 0.04 to 0.2%; Phosphorus - 0.1 to 1.0%; Manganese - 0.2 to 2.0%. The refining process (steelmaking) reduces the concentration of these elements in the metal. A common steel 1020 has the following composition: Carbon - 0.18 to 0.23%; Manganese - 0.3 to 0.6%; Phosphorus - less than 0.04%; Sulfur - less than 0.05%.

Steel Ladle

A vessel for receiving and handling liquid steel. It is made with a steel shell, lined with refractories.

Stools

Flat cast iron plates upon which the ingot molds are seated.

Stoves

Large refractory filled vessels in which the air to be blown into the bottom of a blast furnace is preheated.

Strand

A term applied to each mold and its associated mechanical equipment.

Support Rolls

Rolls used in the casting strand for keeping cast products aligned.

Tap Hole

A hole approximately fifteen (15) centimeters in diameter located in the hearth brickwork of the furnace that permits flow of the molten steel to the ladle.

Tapping

Transfer of hot metal from a furnace to a steel ladle.

Tap to Tap

Period of time after a heat is poured and the other necessary cycles are performed to produce another heat for pouring.

Tar

The organic matter separating by condensation from the gas in the collector mains. It is a black, viscous liquid, a little heavier than water. From it the following general classes of compounds may be recovered: pyrites, tar acids, naphthalene, creosote oil and pitch.

Teeming

Casting of steel into ingots.

Tundish

A preheated covered steel refractory lined rectangular container with several nozzles in the bottom which is used to regulate the flow of hot steel from the teeming ladles.

Vacuum Degassing

A process for removing dissolved gases from liquid steel by subjecting it to a vacuum.

Venturi Scrubber

A wet type collector that uses the throat for intermixing of the dust and water particles. The intermixing is accomplished by rapid contraction and expansion of the air stream and a high degree of turbulence.

Wash Oil

A petroleum solvent used as an extractant in the coke plant.

Waste Heat Boiler

Boiler system which utilizes the hot gases from the checkers as a source of heat.

Water Tube Hood

Consists of steel tubes, four (4) centimeters to five (5) centimeters laid parallel to each other and joined together by means of steel ribs continuously welded. This type hood is used in the basic oxygen steelmaking process for the combustion and conveyance of hot gases to the waste gas collection system.

Wet Scrubbers

Venturi or orifice plate units used to bring water into intimate contact with dirty gas for the purpose of its removal from the gas stream.

TABLE

METRIC UNITS

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS)		by	TO OBTAIN (METRIC UNITS)	
ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/ kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	ton	0.907	kkg	metric tons (1000 kilograms)
yard	yd	0.9144	m	meters

* Actual conversion, not a multiplier